JOB STRESS, ANXIETY AND MUSCULAR TENSION ASSOCIATED WITH MUSCULOSKELETAL DISCOMFORT AMONG VISUAL DISPLAY UNIT OPERATORS

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Gaylia D. Powell

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Abstract

This study was derived from a model of the development and maintenance of occupational pain (Wright, 1987), particularly occupational overuse syndrome. The model suggests that occupational pain is maintained by a pain cycle that has several entry points, including that of psychosocial job stress. Part of the model, starting at this point, led to the proposition that job stress is positively associated with anxiety, the bracing of the muscles of the arms, neck and shoulders, and musculoskeletal discomfort, of keyboard operators. Each of the variables was measured in a sample of 47 male and female visual display unit operators employed by several public and private organisations. Three questionnaires were modified for the purposes of the study: the Stress Diagnostic Survey (Ivancevich, Matteson, & Dorin, 1988), the State-Trait Anxiety Inventory (Speilberger, 1983) and the Nordic Questionnaires (Kuorinka et al., 1987). Surface muscle tension was recorded using electromyography, as subjects worked and stopped working. Results showed some statistically significant correlations between variables, supporting in part the hypotheses tested. Because the study is of cross-sectional design,
cause-and-effect relationships are not conclusive. However, the significance of the results in the prevention of occupational overuse syndrome, by reducing muscle tension, strengthening muscles, and taking rest pauses, is discusssed.

Introduction

The Nature and Cause of Occupational Overuse Syndrome

Occupational overuse syndrome (OOS), commonly known as RSI (repetition strain injury), is a widespread and costly health problem in the workforce. In New Zealand in the year ending 31 March 1989, the Accident Compensation Commission paid out $16.5 million compensation to 6,200 people with RSI-related problems. It can lead to weeks or months, sometimes years, off work, with financial and personal costs to sufferers and their families, and disruption in their workplaces (Bammer & Blignault, 1988; Shadbolt, 1988). Much of the available information comes from Australia, where OOS was seen in epidemic proportions during the 1980's. However the problem is not new, and is included in the literature of the United States, Japan, Great Britain and Scandinavia, under various names, including occupational cervico-brachial disorder and cumulative trauma disorder (Stone,1986). It is prevalent in a wide range of industries, particularly manufacturing. Visual display unit (VDU) operators in white-collar industries are a large group recently affected, and are the subjects of this study.

The National Occupational Health and Safety Commission of Australia (1986) published a definition of OOS that has been adopted in New Zealand (Brown, 1989). The main points are that:

1. The problem comprises a range of conditions.

2. These conditions are characterised by discomfort or persistent pain in muscles, tendons and other soft tissues.

3. There may or may not be physical manifestations.

4. The problem is usually caused or aggravated by work.

5. It is associated with repetitive movement, constrained or sustained postures and/or forceful movements.

6. Psychosocial factors, including stress in the working environment, may be important in its development.

7. Some conditions which fall within the scope of the problem are well-defined and understood medically, but others are not.

However the more recent statement by the Royal Australasian College of Physicians (1989) presents a very different view. The College specifically excludes the well-defined conditions (e.g. tenosynovitis of the wrist and epicondylitis of the elbow), and makes the following points about the remainder, which have well-described clinical features but lack objective signs of injury:

1. The problem is that of a chronic pain syndrome.

2. This chronic pain syndrome is a psychosomatic problem and <u>not</u> an injury caused by work. Ergonomic factors were not the cause of the recent epidemic of this chronic pain syndrome.

3. The rapid and dramatic spread of the epidemic of RSI in Australia related to the propagation of an abnormal community belief about the effects of work on the body.

4. The clinical features seem to be related to increased activation of the small fibre pain nerve system with secondary muscle tightness and effects on circulation. The pain amplification in turn relates to change in central mechanisms of pain which link strongly to psychological events.

5. Exercise and relaxation therapy coupled with early return to work are indicated.

There has been considerable controversy over the aetiology of OOS, as indicated by the contrasting views above and a considerable literature (e.g. Bell, 1989; Chattergee, 1987; Cleland, 1987; Fildes, 1988; Ireland, 1988; Lucire, 1986; McDermott, 1986; Miller & Topliss, 1988; Sikorski, 1988; Spillane & Deves, 1987). Theories range from the standard view that OOS comprises work-related injuries, to those in which the pain is said to be either not "real" (i.e. not organic in origin) or not work-related, or both. For example, sufferers may be malingering or they may have a compensation neurosis (through actual or likely gain from the problem), a conversion disorder or normal fatigue. For reviews of the theories, see Bammer and Martin (1988) and Mullaly & Grigg (1988).

For this research I have made the assumptions that, regardless of whether or not OOS involves injury in the sense of organic damage, the pain and disability is real, and it is caused or aggravated at work, by physical and/or psychological stressors. There is nothing in the literature to suggest that non-work activities are a significant cause of OOS of VDU operators, although they may be contributing factors. Ergonomic research has led to the development of well-documented standards of workstation design for keyboard operators, aimed at minimising physical strain (e.g. New Zealand Department of Health, 1985; New Zealand Department of Labour, 1988; Oxenburgh, 1986). However even in organisations which have applied the principles of safe design of equipment, the problem of muscle pain at work can persist and even worsen (National Occupational Health and Safety Commission, 1986, p. 44). Sometimes tense work habits and other poor skills cause pain at work, and can be remedied (e.g. Patkin, 1988). However persistent pain may also be caused or exacerbated by problems such as stress created by work organisation and social aspects of the workplace, and perhaps of home-life. It is psychosocial stress factors of the workplace, and their possible consequences, that are investigated in this study.

Psychosocial Influences on OOS

Social and organisational factors are frequently mentioned in the literature as causing or exacerbating musculoskeletal pain. For example, the Task Force (1985) report of the Australian Government associated incidence of RSI with the social context of work (e.g. supervisor's style and power relations), attitudes to the job, and stress responses to work. However, there is little empirical research on the influence of these factors on OOS. An exploratory study done for a university thesis (Blignault, 1986) showed that the differences between keyboard operators with frequent musculoskeletal symptoms and those without were mostly related to job characteristics and working conditions, for example lack of control over job activities (i.e. lack of autonomy) and work pressure, rather than to employee characteristics such as age, keyboard experience or life stress. Earlier, Smith, Cohen, and Stammerjohn (1981) found that visual, musculoskeletal and emotional health problems in clerical and VDU operators were associated with high levels of self-reported stress from lack of autonomy, workload, boredom, and concerns about their careers. Linton and Kamwendo (1989) found that a "poorly" experienced psychologic work environment was related to a higher frequency of neck and shoulder pain than a "good" environment, when they examined work content and work demands of secretaries, and their social support at work.

However, it is not necessarily the case that environmental stress actually causes musculoskeletal problems. Such stress might instead influence perception of existing problems. When Magora (1973, cited in Ireland, 1988) studied low back pain, another musculoskeletal disorder which is thought to have a psychosomatic component, he found that the two correlates linking low back pain and work incapacity were: (a) a belief held by the patient that their work had injured their back, and (b) job dissatisfaction. Discussing these results, Ireland (1988) theorizes that, "Although arm pain is a common accompaniment to the activities of daily living, potential RSI sufferers, lacking fulfilment in their work, have been unable to accept this when faced with the notion that repetitious tasks (in which they are employed) cause injury."

Some theorists suggest that sympathy and recognition exacerbate the problem. The Royal Australasian College of Physicians (1989) supports this view. They blame the Australian "epidemic" on the widespread acceptance of OOS by employers, unions and the general public. Kiesler and Finholt (1988) point out, "In Australia RSI is a household concept. Everyone, particularly those in the vulnerable worker groups, is very aware of the alleged causes of RSI, its symptoms, and the fact that the government and businesses believe that RSI is a real disease." Possibly, perception of imminent risk of debilitating injury creates, of itself, workplace stress.

The Role of Individual Differences in the Development of OOS

One would expect that some people would be more likely than others under similar circumstances to be affected by musculoskeletal problems, and in fact only a small proportion of VDU operators develop OOS. Apparently one reliable predispositional factor determined to date is female gender (Kiesler & Finholt, 1988; Miller & Topliss, 1988). These gender differences may be a consequence of psychological, physical or lifestyle differences, or may simply reflect the different occupations in which men and women predominate. Ursin, Endresin and Ursin (1988) studied psychological factors and self-reports of muscle pain among people employed in a variety of industries, and found that women were more affected by muscle pain than men, and psychological variables explained more of the variance in this factor for women than for men.

In a recent controlled study, Kucera (1989) found that workers who develop cumulative trauma disorders of the upper extremity are more likely to exhibit strong hand preference, whether left or right. There is also evidence that some people may have a predisposition to OOS via heightened physiological reactivity to environmental stress. This reactivity may be detected using a Hettinger device which measures change in skin temperature of the hand when the hand is subjected to vibration (Brown, Coyle & Beaumont, 1985; Welch, 1973).

In general, research to determine the psychological characteristics of the likely OOS sufferer has been unfruitful, although consequences of the problem may include chronic pain, anxiety, depression and social withdrawal (Bammer & Blignault, 1988).

A Comprehensive Model

Wright (1987) proposed a model of how ergonomic, work organisation and social factors might contribute to pain through psychological and physiological reactions to stress (Figure 1). This model incorporates what is known as a pain amplification cycle, a physiological system that perpetuates pain and disability once it has become established. The pain of OOS can be located in the hands, forearms, upper arms, shoulders or neck. The entry points to the pain cycle are 'pain' (usually caused by fatigue), 'anxiety/anger' (caused by personal or domestic matters, or factors relating to work organisation or social relations at work), and regional muscle contraction (caused by factors such as constrained posture) (Wright, 1985). Part of the model--job design, work organisation and social aspects creating anxiety, leading to bracing of muscles, leading to pain--forms the basis of this project. If the model is correct, then anxiety and anger, and physiological and health changes, may be a response to psychosocial stress at work. This is quite plausible, given the current understanding of stress, which will be summarized in the next section. However, despite its plausibility, no report that I have found examines such a sequence empirically.

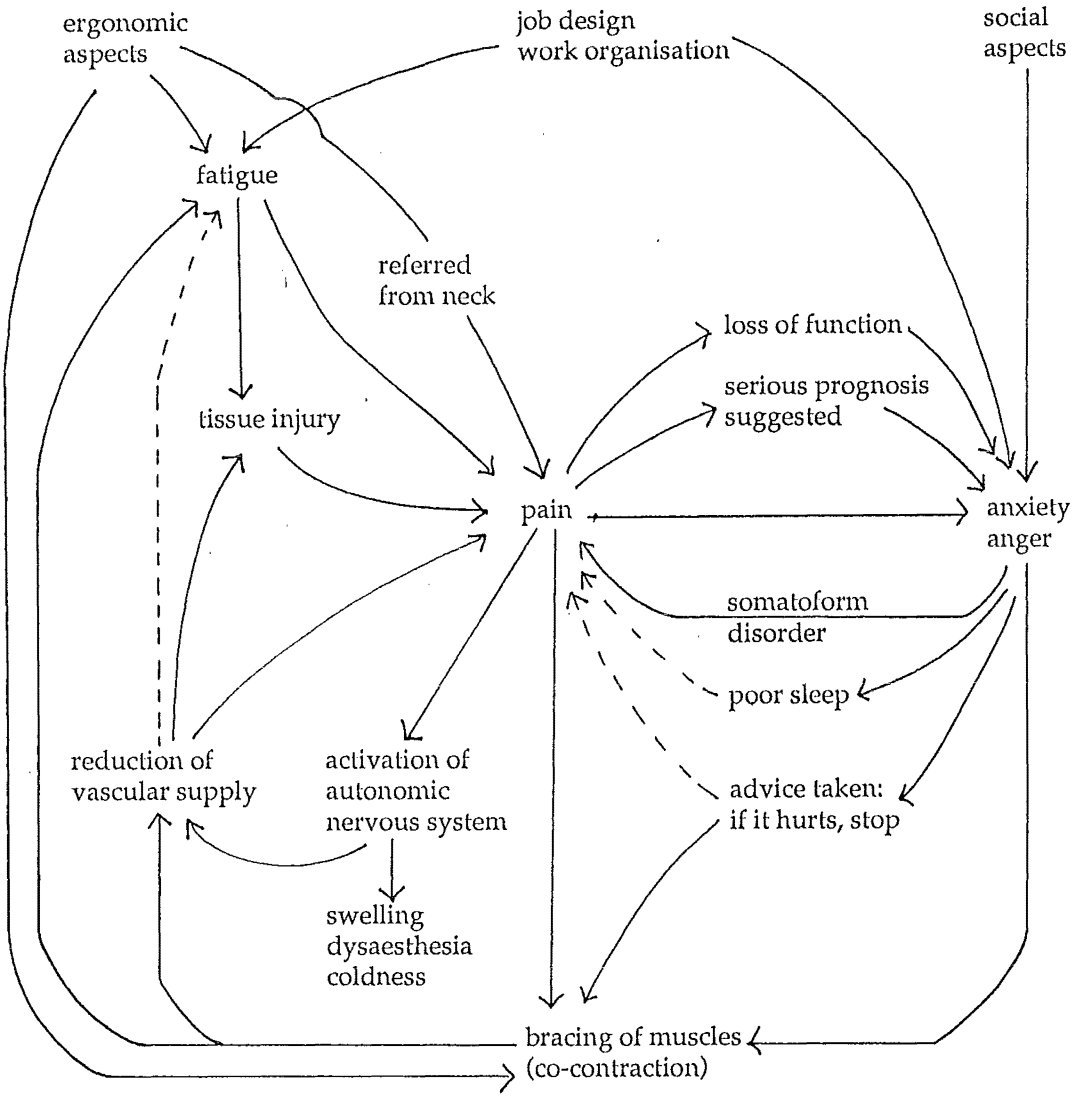


Figure 1. The development and maintenance of occupational pain (Wright, 1987).

The Concept of Stress

The concept of stress is not new; it has been the concern of the medical profession for centuries. For instance, Hippocrates (c460BC - c375BC) separated the suffering caused by disease (pathos) from the effort of resisting and fighting it (ponos), an idea similar to the concept of stress today. However, only since the beginning of the 20th century has research into stress led to the formalization of the concept. Stress is the process by which environmental events threaten or challenge an organism's well-being and by which that organism responds (Gatchel & Baum, 1983). In moderate amounts such challenges provide essential stimulation without which life would be dull, and personal development stunted. Usually, however, excessive stress is thought of as a negative force, both in everyday usage and in the literature of organisational psychology.

The environmental events are called stressors. These may be physical dangers or psychological threats or opportunities external to the organism, or internal representations of threat. They may include anything from a virus to a flood, a social encounter, or a remembrance. Contact with a stressor leads to physiological and emotional responses, or arousal, and psychological appraisal, a cognitive response that is the evaluation of the effects of the stressor and how to deal with these. Coping by behavioural or cognitive means is followed by reappraisal. If the situation is no longer stressful, the effects diminish. Otherwise, the stress response can persist. Thus the perception of threat motivates a search for coping responses that will reduce the problem. The three reactions, arousal, appraisal, and coping behaviour, are all significant in the understanding and measurement of stress at work, and so will be elaborated.

Arousal. The heightened arousal state in reaction to danger was described by Cannon (1929, cited in Gatchel & Baum, 1983, p. 43), a pioneer in physiological psychology, as the "fight or flight response", totally appropriate to human encounters with beasts and enemies. Such arousal may provide a biological advantage to the organism, by enabling it to respond more rapidly to danger, and thus facilitating adaptive behaviour. However, the value of such a response, especially when sustained over long periods, is less obvious in the context of present day pressures at work. In fact, arousal has been associated with impaired performance on complex tasks.

The physiological response of an organism to stress seems to be fairly non-specific--physiological arousal and related somatic changes are similar for most stressors. It involves the activation of the sympathetic nervous system, which simultaneously speeds up the heart, dilates the arteries of the skeletal muscles and heart, constricts the arteries of the skin and digestive system, and causes perspiration. It also activates certain endocrine glands to secrete hormones that further increase arousal. Fortuitously for research, such hormones can be used as indicators of arousal. These include the neurotransmitter catecholamines, and epinephrine (adrenaline) and norepinephrine (noradrenaline), and the corticosteroids, particularly cortisol.

Appraisal. Lazarus and Folkman (1984) emphasise the role of perception and cognitive appraisal in the stress response. They suggest, for example, that unless we perceive a situation as threatening, we will not experience stress. A series of studies conducted by Lazarus and his associates during the 1960s provide convincing evidence that stress is not well understood in situational terms alone. Whereas some stressors are very intrusive, physical and universally threatening (e.g. natural disaster), others are more culturally determined, and so must be influenced by appraisal. Crowding and spatial invasion, for example, are culture-bound in that responses to varying densities and proximities are specific to cultural norms and meanings.

Coping behaviour. Lazarus proposed that stress responses can take manipulative or accommodative forms. They may be:

(a) direct action response (e.g. change setting, flee, remove stressor),

(b) seeking information so as to understand a situation and predict events (and in so doing, gain some degree of control),

(c) inhibition of action (i.e. do nothing), or

(d) intrapsychic or palliative coping (e.g. reappraise a situation or alter the "internal environment" with drugs, relaxation techniques, or the use of psychological mechanisms, conscious or otherwise).

Stress and Emotion

Emotion is an important component of the stress process. Cannon (1929, cited in Gatchel & Baum, 1983, p. 43), studying emotion early in the twentieth century, was among the first to use the term stress. The non-somatic feelings that we have when stressed--anxiety, annoyance and so on--are emotional responses to threat or harm. The physiological systems through which emotion and stress appear to be channelled are similar, both being heavily influenced by sympathetic arousal. The emotional experience is also closely linked with appraisal, with any of wide range of emotions being determined by the circumstances. They might be pleasant or unpleasant, mild or strong, including fear, anger, anxiety, excitement and curiosity, for instance. These emotions typically motivate people to try to dispel, avoid, overcome or prolong the source of the arousal, something akin to the coping behaviour of the stress response. More importantly, the form of response to stress is likely to be affected by emotional responses associated with the event. For example, if we respond angrily, our coping is likely to be more forceful and active than if we respond with sadness and despair. The emotional consequences of stress need not be severe, and yet they are generally negative, for example increases in impatience, irritability, emotionality, and feelings of worthlessness.

Anxiety

Anxiety is a complex emotion that is frequently associated with stress; any situation that threatens the well-being of the organism is assumed to produce a state of anxiety (Atkinson, Atkinson, & Hilgard, 1983, p. 431). There is no one accepted definition of anxiety, but the term is normally used to describe an unpleasant emotional state characterised by feelings of worry , tension, unease, apprehension, or fear, and also by arousal of the autonomic nervous system, in response to certain stimuli. These anxiety-producing stimuli do not have similar effects on everybody: some people seem to be habitually more anxious than others, reacting to situations that might not be productive of anxiety in others, and reacting more strongly. That is, there are relatively stable personality differences among people in the tendency to perceive stressful situations as dangerous or threatening and to respond to such situations. This personality characteristic, known as trait anxiety, reflects residues of past experiences, particularly during childhood. The stronger the anxiety trait, the more probable that the individual will experience more intense elevations in state anxiety, that is, anxiety as a transient emotional reaction, when a threatening situation arises. High trait anxiety persons are particularly likely to respond with greater increases in the intensity of state anxiety in situations that involve interpersonal relationships and threaten self-esteem. In such situations, state anxiety may vary in intensity and fluctuate over time as a function of the amount of stress that impinges upon the person; but the individual's perception of threat may have greater impact on the level of state anxiety than the real danger associated with the situation.

If it is assumed that anxiety is an emotional state or a personality trait, then it cannot be measured directly. However it can be inferred from various types of evidence, and measures have been developed accordingly. Such evidence includes introspective reports, physiological signs, task performance, responses to stress and gross behaviours such as posture. Many scales have been constructed which aim to measure subjects' self-reports of feelings indicative of anxiety.

Measurement of Stress

Because of individual differences in appraisal, the effects of psychological stressors cannot be measured directly, but rather must be defined in terms of the situations in which they arise, or be inferred from responses. Negative mood states, performance changes on some tasks, and increased secretion of catecholamines by the adrenal glands, for example, all allow inferences to be made about stress. The refinement of measurement techniques allows estimates of hormone levels to be made from urine and plasma samples; people can be asked how they feel; and their behaviour can be observed. For discussion of the issues of occupational stress research, see Hurrell, Murphy, Sauter, and Cooper (1988). For stress and health, see Kasl and Cooper (1987), and Mackay and Cooper (1987).

Stress and Health

Most of the research that finds support for facilitating aspects of stress, has considered acute situations in which adjustment leads to reduction of stress. However, Cannon (1935, cited in Gatchel & Baum, 1983, p.43) described critical stress levels as threats or dangers that affect an organism sufficiently so as to disrupt homeostasis (organic stability, or equilibrium), and throw the organism off balance. Thus stress can lead to disruption of emotional and physiological stability as well as aid in survival.

The consequences of unabated stress or repeated exposure to stress have more recently come under study. Among these consequences are decrements in ability to cope with subsequent stress, physiological dysfunction, and in some cases, tissue damage, or death (Selye, 1976). Selye (1973), who studied biologic stress, used a concept called the general adaptation syndrome (GAS) to describe the process involved. The importance of this is in its depiction of how stress can lead to resistance and physiological damage. The GAS consists of three stages of response:

1. As the organism becomes aware of a stressor an alarm reaction is experienced. The organism prepares to resist the stressor with the non-specific physiological changes already described. Adrenal activity and cardiovascular and respiratory functions increase and the body is made ready to respond.

2. When reserves are ready, the organism enters a stage of resistance, applying various coping mechanisms and typically achieving suitable adaptation. During this stage, there is relatively constant resistance to the stressor, but a decrease in resistance to other stimuli.

3. When these reactions are repeated many times, or when the problem is prolonged, the body continues to activate body defense systems until a state of chronic chemical imbalance is achieved. Selye believes that this third stage of the GAS, exhaustion, may lead to diseases of adaptation, such as arthritis and cardiovascular damage (via prolonged high levels of catecholamines).

Selye's work did not include psychological precipitation of stress, but a major development in stress research since, has been the integration of psychological mechanisms into an essentially biological model. Frankenhaeuser (1975) demonstrated the pervasive role of psychological factors in elicitating a primary physiological symptom of stress. Frankenhaeuser's work also suggests a kind of nonspecficity, not unlike Selye's. The same bodily response--secretion of epinephrine and norepinephrine--seems to occur in the face of a wide range of psychological events, including job dissatisfaction, loss of control, conflict, and boredom. The importance of this is that if psychological factors can alter bodily functioning in ways that facilitate illness, for example, an important link between psychology and health has been revealed.

It is obvious that stressful situations that may create ill health in one person, do not necessarily in others. Some divergent responding may be based on biological predisposition, but the evolution of psychological mechanisms as a part of the stress process helps to explain variation in responses to stress. In particular, research has focussed upon individual differences of four kinds: (a) perception of risk, (b) social support, (c) dispositional variables, and (d) control.

Perception of risk. There are a number of factors responsible for individual differences in appraisal of a potential stressor. Some studies have suggested personality differences--dispositions, or tendencies, to appraise events in particular ways. Moreover, attitudes towards sources of stress act as filtering devices that moderate perception of the stressor. Assessment of risk appears to be influenced by biases in perception and judgment. In situations in which hard or clear evidence is not immediately available, individuals are likely to use general inferential rules or guidelines known as heuristics--shortcuts that sometimes yield inaccurate evaluations and may also lead to a greater degree of confidence in one's own judgement than is warranted.

It is because of these differences in perception and judgment (or decision making) that in research that concerns the outcomes of stress, it may be appropriate to target perceptions of stress rather than attempt to measure assumed stressors.

Social support. Research on social support and recovery from illness, psychological adjustment to grief and bereavement, job loss and threat of death or injury, has provided evidence of the beneficial effects of social support.

Dispositional variables. Coping styles or behaviour patterns have been identified, and these appear to affect the ways in which events are appraised, as well as which types of coping are involved. For example, individuals who manifest a Type A behaviour pattern interpret most threats to control as stressful. Their appraisal of events is particularly sensitive to anything that might reduce their control over a situation.

Control. Perceived control is a powerful mediator of stress, providing individuals with a sense that they can cope effectively to predict events and so determine what will happen. For instance, in the work situation, the perception of being able to influence decisions and conditions which affect them is a strong predictor of positive or negative outcomes. This is not surprising, given the interactional nature of stress. For a worker who has no control over a given threatening situation, the possibilities for coping may be restricted to psychological responses, such as denial, which may or may not reduce stress in the long term. On the other hand a worker who does have control in the work environment may be able to select from a range of adaptive responses which could dispel the threat altogether.

Types of Stress

Although some events are threatening to almost no-one, most carry a range of potential problems. Some or all of these problems may be appraised as stressful under some conditions. The properties of the stressor can affect the appraisal made of it but cannot ordinarily determine reactions directly because of the individual differences in appraisal and coping styles already discussed.

Lazarus and Cohen (1977, cited in Gatchel and Baum, 1983, p. 55) have described three general categories of stressors drawn along a number of dimensions, including how long the stressor persists, the magnitude of the response required by the stressor, and the number of people affected:

1) Cataclysmic events are stressors that have sudden and powerful impact and are more or less universal in eliciting a response, for example war or a natural disaster.

2) Personal stressors such as the loss of a spouse are also strong and may be unexpected. Included are those events powerful enough to challenge adaptive abilities in the same way as do cataclysmic events, but that affect fewer people at any one time.

3) Background stressors are persistent, repetitive and unavoidable; that is stressors that are part of our everyday lives. Lazarus and Cohen have labelled this third group, daily hassles. They are the stressors most relevant to organisational psychology, and include living or working in a noisy environment, overcrowding, and job dissatisfaction. Such factors affect large numbers of people on an *individual* basis, but they are considerably less powerful than cataclysmic events or personal stressors. It is the fact that they are chronic which is significant. Background stressors push an individual's adaptive abilities toward their limit. By requiring that people allocate attention and effort to them, they may gradually reduce an individual's ability to cope with subsequent problems. At some point these daily hassles may exceed one's adaptive abilities, resulting in too much wear and tear on the body, and placing one at risk for major psychological and physiological response to acute stressors (Lazarus, 1981).

Occupational Stress

Occupational stress, the stress experienced in relation to one's work, is a popular recent research topic, reviewed in numerous recent books and journals. Levi (1981) defined occupational stress as a state of unpleasant emotional tension seen to arise in work settings where discrepancies exist between occupational demands and opportunities on the one hand, and the worker's capacities, needs and expectations on the other. That is, stress occurs where there is a "lack of fit" between person and environment or where an environment fails to meet a person's energy resources, a commonly accepted view which takes into account the individual differences between people.

Many sources of occupational stress have been defined. The relative importance of these varies according to occupation, type of organisation, the employee's place within it, and personal factors such as his/her career stage. However, there are a number of general sources of work stress which are mentioned repeatedly in the literature. These include: (a) factors intrinsic to the job (e.g. poor physical working conditions, responsibility for people), (b) role in the organisation (e.g role ambiguity, boundary conflicts), (c) career development (e.g. overpromotion, thwarted ambition), (d) relationships at work (e. g. poor relationships with others, difficulties in delegating work), and (e) organisational structure and climate (e.g. little participation in decision-making, office politics) (Cooper, 1986). A model of stress at work (Figure 2, Hornblow, 1988) illustrates how these sources of stress may interact with psychological and situational aspects of a person to determine health and organisational symptoms and outcomes.

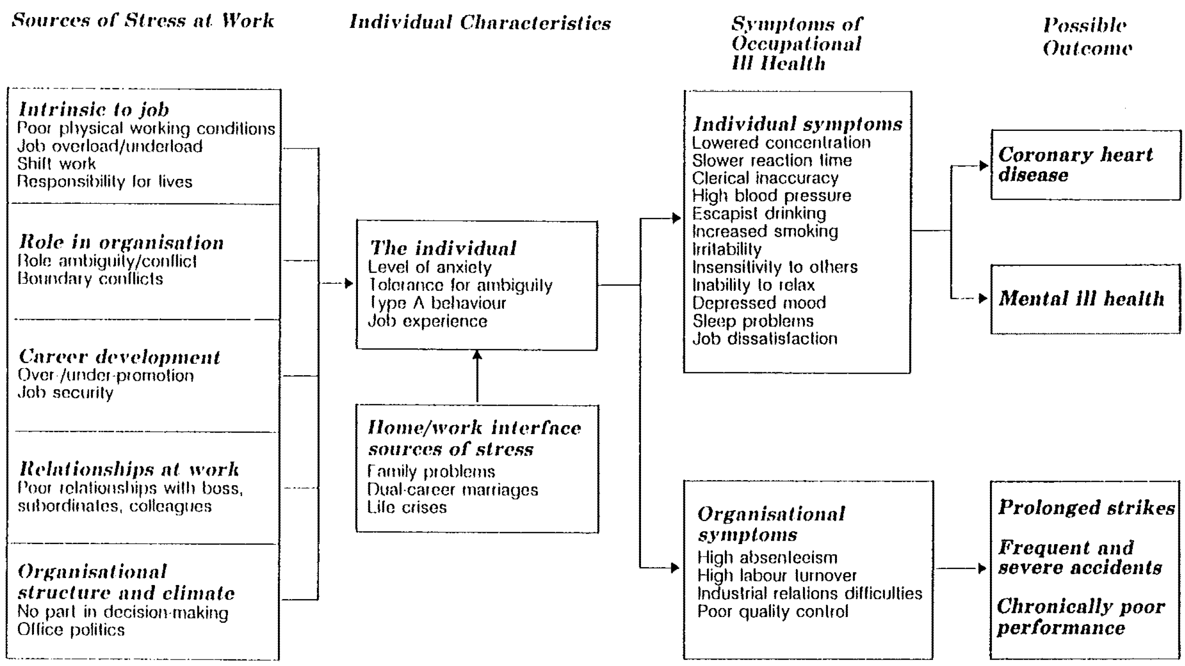


Figure 2. A model of stress at work (Hornblow, 1988, adapted from Cooper, 1986).

Occupational Stress Among Visual Display Unit Operators

Knowledge of possible health effects of VDU work, either in the short or long term, is still incomplete, but a number of studies have addressed this group. (See review by Dainoff, 1982.) The work of VDU operators cannot be considered to be uniform in either content or effect. On the one hand, such work may be interesting, varied and highly skilled, the computer being used as a tool to extend the information-processing capacity of its user. On the other hand, VDU work may be simple and repetitive, requiring minimal involvement of the operator, and affording little control. In the study by Smith et al. (1981), clerical VDU operators reported higher levels of job stress and health complaints (but little difference in psychological mood state) than did professionals using VDUs or non-operator control subjects. The job stressors showing the greatest impact on the clerical operators concerned workload, lack of control over job activities, boredom, and concerns about career development. The health complaints that showed the greatest differences between the groups were visual, musculoskeletal, and emotional health problems. Smith et al. conclude that job content factors and VDU use interact to contribute to VDU operator problems.

The perception of lack of control is one of the factors clearly related to symptoms of occupational stress (e.g. Perrewe & Ganster, 1989). In the context of VDU work, the quantity of work may be monitored by the machine, and this information used to determine remuneration via piece-rate systems. Such control may be regarded with suspicion, and can be associated with feelings of fatigue and stress. Long response times from the computer, or those that are variable in length, cause uncertainty and frustration. These problems may be exacerbated by technical disturbances and breakdowns when these occur frequently. Johansson and Aronsson (1984), comparing VDU operators with non-VDU clerical workers, showed that the effects of machine control over the organisation of work may lead to marked psychological arousal as evidenced by increased urinary catecholamine levels. These effects are slow to subside when the person has stopped working, and Johansson and Aronsson point out that this may be a mechanism in the development of stress diseases.

Rationale

Based upon Wright's (1987) model, the research presented herein attempts to answer the following question: Is psychosocial stress in the workplace (henceforth called job stress) associated with: (a) anxiety, (b) bracing of muscles of the arms, neck, and shoulders, and (c) pain or discomfort in the arms, neck, and shoulders of VDU operators? The expectation is that this is so. Therefore, correlations between measures of these factors in a sample of people at work should be revealed. The distinction is made between state and trait anxiety, because the habitual anxiety of some people may lead to bracing of muscles irrespective of job stressors. Furthermore, such anxiety may amplify perceived job stressors and through physiological mechanisms, pain (Gatchel & Baum, 1983).

Wright's model implicates anger as well as anxiety as a cause of muscle tension, but this idea is not pursued here. It is less obviously implicated, given that overuse sufferers are often reported to be conscientious workers who want to get back to work (free of pain), and not angry people (e.g. Wigley, 1990).

Neither does this research look at reduction in blood supply. From a physiological perspective it is an obvious and necessary consequence of muscle tension.

The purpose of the study lies in the possible application of the findings to prevention of overuse problems. Current treatments, including rest, splinting, physiotherapy, psychotherapy and surgery, are failing to solve the problem, and may in fact be counter-productive (Sikorski, 1988). However Brown (1989) offers a preventative approach which has been found to be extremely successful in previously troublesome sections of the Australian workforce. This approach is based upon the contention that OOS is caused by muscular tension. Tension impedes the flow of blood in the muscles, resulting in an inefficient anaerobic energy conversion process, with consequent build-up of lactic acid, and muscle fatigue, which causes the pain. (Note that the Royal Australasian College of Physicians (1989) also implicates muscle tightness and effects on circulation, but as an effect rather than cause of pain.) Direct and indirect methods of reducing muscle tension are applied, and the effectiveness of these methods can be demonstrated using an electromyograph (EMG) recorder. The methods used target a number of possible causes of muscle tension. They include application of ergonomic principles to workstation adjustment, operator training in relaxed work style (including the use of EMG biofeedback), introduction of exercises at the workplace to relax muscles (by contracting antagonistic muscles) and increase the bloodflow, changes in job design to build short rests (called micropauses) into the work or vary the nature of the work to allow muscle recovery, and changes in organisational climate to reduce stress.

The intervention described appears to be compatible with the approach advocated by the Royal Australasian College of Physicians, albeit more comprehensive. It is also compatible with the Wright (1987) model, although it is not clear which of the many strategies are actually responsible for the cessation or prevention of symptoms, or their relative efficacy.

Yet despite the apparent effectiveness and the plausibility of this approach, particularly the training in relaxed work style using EMG biofeedback, it is not much practised locally. The use of my study, therefore, may be that if the sequence described above can be demonstrated, then the idea of teaching methods of anxiety reduction or muscle tension reduction to VDU operators might gain credibility. That of course could give concerned employers and operators confidence in these means to help themselves combat the perplexing workplace problems of OOS and less serious discomforts. Some job stress is inevitable, but if stress can be shown to be an important factor in the pain sequence, then that will need attention too.

In this study, each of the four factors is measured in a sample of VDU operators. Modifications of previously developed questionnaires are used for assessing perceived job stress, anxiety and musculoskeletal discomfort. No attempt is made to diagnose either chronic pain syndromes or the well-categorized musculoskeletal injuries; instead, self-reported experiences of pain or discomfort in specific body regions are measured. This technique is used in epidemiological studies (e.g. Slappendel, 1989).

Muscle tension is measured as subjects pursue their normal keyboard work. Also, in order to avoid the problem of the enormous variation in muscle tension as people work (because of differences in keyboards, furniture, style of working and the kind of work), another dependent variable measured is Recovery Time, that is the time for the muscles to relax when the subject stops keying. The assumptions here are:

1. If work stress is reflected in higher muscle tension, then it will affect the time it takes an operator to relax when (s)he stops keying.

2. As muscles are built to work, but not to sustain unrelieved tension over long periods, the ability of the operator to relax them between keying tasks to allow the blood to circulate, may distinguish people with aches and pains at work from those without. Regional muscle spasm and high muscle tone are characteristically present when a pain cycle is present. People who have injured a body part may have difficulty relaxing that part, prolonging healing time or predisposing the part to further injury. Therefore it may be possible to detect a relationship between Recovery Time and reported musculoskeletal problems.

Hypotheses

Hypothesis 1 *Greater perceived job stress will be reflected in greater anxiety at work of keyboard operators.*

Hypothesis 2 *Higher levels of perceived job stress and anxiety at work will be reflected in greater muscle tension of the shoulders or forearms of keyboard operators, as measured by electromyography.*

Hypothesis 3 *Greater job stress, anxiety at work and muscle tension of the shoulders or forearms will be associated with more prevalent and/or more serious musculoskeletal complaints of the shoulders, neck, arms and back of keyboard operators.*

Hypothesis 4 *Keyboard operators who perceive higher levels of job stress will take longer to relax at the end of the working day than at the beginning.*

The investigation that follows is an attempt to test these sequentially linked hypotheses.

Method

Subjects

Forty-seven visual display unit (VDU) operators from five organisations participated in the study, 36 women and 11 men. Their ages ranged from 18 to 54 years, the average age being 32 years. All the subjects worked in offices for at least 30 hours per week, exept one woman who was temporarily restricted to 25 hours per week during treatment for arm pain. Seventy-two percent of the subjects worked between 37 and 40 hours per week. Only 2 worked more than 45 hours, at two jobs. All but six had been employed in keyboard work for at least a year, the average being almost 8 years. All were paid salary or wages, rather than piece rates, but in one workplace operators had the incentive of leaving early if all the work was completed. In two workplaces operators received a weekly printout of keystrokes and errors.

The employing organisations included a bank, a government department, a newspaper publisher, a television station and a data bank. These were all large organisations which had experienced overuse problems amongst their employees in the departments concerned. All the organisations in the study provided adjustable desks, chairs and VDU screens, and where appropriate, document holders. Some of the subjects had wrist supports. (Workplaces which did not have furniture purpose-built for VDU work were deliberately excluded, because it was predicted that the relationships sought between psychological variables and muscle tension would be masked by the effects of ergonomic problems.) The work varied considerably among organisations, but was similar for subjects within each organisation. The kinds of keyboard work done included updating of customer records, right-handed data entry, subtitling and editing of television news programmes, and subediting of newspaper articles.

Materials

Measurement of job stress. Perceived job stress was measured with the Stress Diagnostic Survey Form B developed by Ivancevich, Matteson, and Dorin (1988), which was called *Sources of Job Stress* (Appendix D). The 68-item self-report inventory asked respondents to rate on a 7-point scale, from "never" to "always", the frequency with which the condition described by each item was a souce of stress to him/her. The individual items related to 17 different dimensions, or constructs, of organizational psychology, defined by Ivancevich et al. as follows:

Politics - the extent of stress created because politics rather than performance affect organizational decisions;

Human Resource Development - the extent to which the lack of training and development opportunities contributes to stress;

Rewards - the extent of stress created by the lack of relationship between performance and rewards;

Participation - the extent of stress created because management is not receptive to input from employees;

Underutilization - the extent of stress created because job assignments are not challenging and do not require full use of skills and abilities;

Supervisory Style - the extent of stress created because the quality of supervision is felt to be inadequate;

Organization Structure - the extent of stress caused by structural factors;

Work Flow - the extent of stress caused by paperwork peripheral to function of the job;

Role Ambiguity - the extent of stress created because an individual does not clearly understand the job;

Role Conflict - the extent of stress created because an individual is presented with uncertain demands or an unclear chain of command;

Quantitative Overload - the extent of stress caused by too great a volume of work;

Qualitative Overload - the extent of stress created by job requirements which exceed the individual's ability or skill level;

Career Progress - the extent of stress created by not having enough opportunities to advance and/or to learn new skills and techniques;

Responsibility for People - the extent of stress because of personal feelings about being responsible for other employees;

Time Pressures - the extent to which unreasonable deadlines and time demands are imposed;

Job Scope - the extent of stress caused by the general range and depth of the job;

Technology - the extent of stress caused by a lack of advanced equipment, or training in its use.

Because this questionnaire was fairly time-consuming, taking 10 minutes or more to complete, and would possibly have been too difficult for some subjects, it was presented as an optional questionnaire. It was completed by 34 subjects. However all participants completed a five-item questionnaire called *Pressure/Strain Questionnaire* (Appendix C) which was developed by the same author. This simple questionnaire asked about feelings of pressure or strain in a more general sense, again using a 7-point scale. "Stress" was defined as "existing whenever you experience feelings of pressure, strain or emotional upset at work". The Pressure/Strain Questionnaire with this definition was attached in front of the Sources of Job Stress Questionnaire.

Measurement of anxiety. The STAI (State-Trait Anxiety Inventory, Form Y, Speilberger, 1983), called the *Self-Evaluation Questionnaire,* was modified to measure anxiety at work and away from work by changing the instructions slightly. The STAI is a standardised and widely used measure of psychological distress (Chaplin, 1984) and one which enables a distinction to be made between anxiety at a particular time (state anxiety) and usual or habitual anxiety level (trait anxiety).

Measurement of muscle tension. Muscle tension of each subject was recorded on the *Electromyography Data Sheet* (Appendix E) using an electromyography (EMG) meter called the *Muscle Biofeedback Monitor* (Specifications, Appendix F) and disposable cardiac monitoring electrodes. The threshold knob of the meter was set on the maximum voluntary contraction (MVC) setting so as to give microvolt readings in whole numbers (rather than to one decimal place) for ease of reading the meter. The sound was turned off so that the monitor would not give biofeedback. The timing of the muscle tension readings was determined using a conventional stopwatch in conjunction with a small piece of equipment that emitted a beep every 10 seconds through an earpiece worn by the investigator.

Measurement of discomfort. The standardised Nordic questionnaires for the analysis of musculoskeletal systems (Kuorinka et al., 1987) were modified to produce the *Questionnaire about Back and Arm Trouble* (Appendix G). This questionnaire was used to collect some information about the subject's age, handedness, work, keyboard experience, basis of remuneration, and strategies to prevent or alleviate discomfort at work. The questionnaire also asked about recent experience of trouble at work with the neck, shoulders, elbows, wrists/hands, upper back and lower back. A question about causal beliefs was also included for those with musculoskeletal trouble. "Trouble" was defined as ache, pain, or discomfort.

Procedure

Before any organisations were invited to participate, approval of the project was obtained from the Health and Safety Coordinator of the New Zealand Council of Trade Unions. Subsequently, relevant unions were contacted prior to data collection, either directly, or through the union representative in a workplace. Seven organisations were approached individually by letter with an enclosed proposal (Appendix A) during August and September, 1990. Five agreed to allow their employees to participate, and provided a list of volunteers who met the research criteria of working a full day, and much of this time with a keyboard at an adjustable workstation. Supervisors were provided with a letter for each volunteer (Appendix B) explaining the nature of the research, the requirements of the researcher, the voluntary nature of participation, the right of volunteers to withdraw at any time, and the confidentiality of the findings. Volunteers and organisations were promised feedback on the outcome of the study. The researcher visited three of the workplaces before data collection to talk to supervisors and subjects. Arrangements were made to collect the data from each subject within the first two hours and the last two hours of one work shift. In several workplaces where employees' shifts were slightly staggered, it was possible to collect the data from as many as six subjects on any one day, but usually 3 or 4 participated at a time. Data collection required from 2 to 4 days at each workplace.

Data collection early in the shift. The first EMG measurements taken involved the body of muscle on the top of the right forearm, that is the muscles that are used at the keyboard for the backwards extension of the hand. The back of the subject's right forearm was wiped thoroughly with colourless methylated spirits on a small towelling square, to make certain that it would be free of grease and dead skin. In a single case the left arm was used (and later in the procedure, the left shoulder), with a subject who typed almost exclusively with his left hand. The other 6 left-handers in the study used the right hand or both for typing, and so the right arm and shoulder were used in the study. A tape measure with a cardboard template was used to determine the appropriate placement of the two monitoring electrodes, 2.5 cm apart over the body of muscle along the back of the arm, one third the distance from the elbow crease to the wrist. Appendix H shows the placement positions of these monitoring electrodes, described by Basmajian and Blumenstein (1980). The positions were marked with a ballpoint pen so that later in the day new electrodes could be placed in exactly the same places. This was important for comparison of readings taken at the different times of day, because the voltage recorded by the EMG increases with the area of muscle between the electrodes. Two electrodes were pressed firmly onto the skin at the marked positions and a third, the reference electrode, was applied further down the arm towards the wrist. The wires of the EMG meter were clipped to the electrodes, the two red wires to the monitoring electrodes, and the black wire to the reference electrode.

The subject was instructed to sit comfortably, ready to work, and then rest both forearms in his/her lap and relax, with the following instructions:

> "Let your hands relax and soften. Just let them lie there and do nothing at all. As your hands relax, these muscles in your forearm become soft and loose. That's good, relax completely".

If the lap was not a relaxed position for a particular person, then other positions were tried: first hands on the desk to the sides of the keyboard, and then hanging loose at the sides of the chair. For nearly everyone, however, the lap position gave satisfactory readings on the meter, that is, less than 3 microvolts (µv). Once the tension readings stabilised, allowing up to 15 seconds if necessary, this baseline tension was recorded.

The subject was instructed to continue with his/her work until the researcher said, "Stop *now*" (i.e. stop on the "now"), and then relax the arms in the predetermined position. Each subject was given two practice runs of this, with verbal encouragement if necessary, but not feedback from the EMG meter. Then the measurement sequence began: The subject was told to continue working and that he/she would be stopped again only after typing for 2 minutes, but otherwise the procedure would be the same. The stopwatch was started and 1 minute of keyboard work was allowed for tension to stabilise. Then seven muscle tension readings were taken at 10-second intervals over the 2nd minute to determine *Working Muscle Tension*. When the subject was asked to stop working, the stopwatch was used to determine *Recovery Time*, that is the time for the muscles to relax to 3 μv, or until 15 seconds had elapsed, whichever was first. The measurement sequence was repeated twice in order to give three sets of readings. Then a third variable, *Maximum Voluntary Contraction* (MVC) of the forearm muscles, was determined for all subjects except a few who were currently experiencing arm pain: The subject was asked to rest the right forearm on the table and try as hard as possible to extend the hand (by bending back at the wrist) against resistance applied by the researcher. The researcher pressed down hard enough that the subject could not actually succeed in raising the hand, because bending the wrist shortens the muscles being measured, increasing the number of muscle fibres between the electrodes, and therefore increasing the EMG signal. The maximum EMG reading over 3 seconds was recorded, and the subject was asked to relax.

The whole process was then repeated with the upper fibres of the trapezius muscle on top of the right shoulder. The electrodes were moved from the arm to the shoulder, and discarded later after the shoulder measurements had been taken. As shown in Appendix H, the electrodes were placed either side of a point one-third of the distance from the lowest neck vertebra, C7, to the angle of acromium at the end of the shoulder. This time only one start/stop practice run was made. The instructions given were:

> "This time when you relax your hands in your lap [or other predetermined position] think about your neck and shoulders. Relax them completely. Drop your shoulders and feel your neck go soft and loose. That's fine".

For the measurement of Maximum Voluntary Contraction of the trapezius muscle, the subject was asked to extend the right arm out in front at shoulder level, and to push the straight arm upwards against resistance applied by the researcher for 3 seconds. Half a minute later, this was repeated with the arm extended out to the side. The higher of the two readings was recorded as the MVC.

When the electromyography was completed, the person was given a large envelope and the questionnaires, with instructions to complete them during the day, ready to be collected at the next session of electromyography. Although all the questionnaires had been designed for self-administration, the subject's attention was drawn to the main points in the instructions of each questionnaire.

Data collection late in the shift. During the last 2 hours of the shift, the entire process of electromyography measurement was repeated, at the same workstation, but with just one start/stop practice for both arm and shoulder. Then the pen markings were rubbed off with methylated spirits, and the questionnaires were collected. The Questionnaire about Back and Arm Trouble was checked for completeness, and if necessary the respondent was asked to fill in missing data. His/her latest average keystroke rate was noted if this information was available.

Results

Data were analyzed using the SPSSX computer programme on the VAX computer. Most of the analysis was by Pearson product-moment correlation, with regression analysis where indicated. Analysis of variance was used to test for differences between some groups of subjects. First, indices of job stress, anxiety, muscle tension and musculoskeletal trouble were calculated. Then all these variables were tested for correlation with one another.

At the beginning of this chapter, the four kinds of data are discussed separately. All the variables are listed in Table 7, by way of a summary, before the intercorrelations among the variables and tests of the hypotheses are presented. Unless specified otherwise, probability levels given for correlations are for one-tailed tests, as the directions of the relationships were predicted.

Job Stress

From the questionnaire, Sources of Job Stress, the 17 dimensions of stress were calculated by finding the average score of the four questions relating to each dimension. Each of these dimensions correlated significantly with the mean of all the responses, $r \geq .40$, $p < .05$. Also, 90 of the 136 pairs of dimensions correlated significantly ($p < .05$). Therefore the mean of all the responses was used as a variable called *Stress*.[1]

Footnote

[1]Perceived work stress measured by the Stress Diagnostic Survey (Sources of Job Stress) was regarded as a single measure by Johnson (1989), on the basis of a principal components factor analysis. One factor was retained by the Mineigen criterion, accounting for 86% of the variance. The internal consistency of the measure (Cronbach's alpha) for the sample of 108 female clerical workers was .95.

Data from the shorter Pressure/Strain Questionnaire were averaged to give a variable called *Strain*. The weak correlation between Strain and Stress showed unexpectedly that they were not statistically related, $r = .14$, n.s.

Table 1 shows statistical details of the Stress and Strain scores.

Table 1

Stress and Strain Scores

Variable	*Mean*	*SD*	*Range*	*N*
Stress	3.0	0.7	1.8 - 4.7	34
Strain	3.0	0.8	1.4 - 4.6	47

Note. For both Stress and Strain, the possible range was 1 - 7.

For Strain, 49% of the scores obtained fell into the low stress region (i.e. mean score 1 < 3) and 51% fell into the moderate stress region (3 < 5), with no subjects' scores falling into the high stress region (5 - 7). For Stress, 59% of the scores obtained fell into the low stress region with the remaining 41% in the moderate stress region. The mean score of the sample for each individual dimension of stress also fell into the low or moderate stress region. However, for every dimension except Organization Structure, Role Ambiguity, and Responsibility for People, some subjects reported high stress. When compared with norms supplied by the publisher for information systems and clerical workers in the United States, individual dimension means in this study were lower, except for Career Progress, Responsibility for People, and Job Scope.

The correlations of Stress and Strain with each of the 17 dimensions of stress are presented in Table 2. As the table shows, the only dimension of stress which correlated significantly with Strain was Organization Structure.

Table 2

Correlations of Stress and Strain with the Dimensions of Stress

Dimension	Stress	Strain
Politics	.65 * *	.08
Human Resource Development	.74 * *	.22
Rewards	.69 * *	.11
Participation	.62 * *	-.10
Underutilization	.60 * *	.05
Supervisory Style	.66 * *	.12
Organization Structure	.62 * *	.35 *
Work Flow	.40 *	.02
Role Ambiguity	.65 * *	.03
Role Conflict	.66 * *	-.10
Quantitative Overload	.68 * *	.22
Qualitative Overload	.53 * *	-.07
Career Progress	.72 * *	.13
Responsibility for People	.65 * *	.07
Time Pressures	.56 * *	.26
Job Scope	.81 * *	.04
Technology	.55 * *	.17

$^{*}p < .05$. $^{**}p < .001$.

Anxiety

Anxiety scores, that is *Anxiety at Work* and *Trait Anxiety* (anxiety away from work), were calculated from the Self-Evaluation Questionnaire and are shown in Table 3. Anxiety away from work is called Trait Anxiety, because it is conceptually so similar to Speilberger's trait anxiety, as well as being measured by the same scale. Mean anxiety scores for the two age groups, 39 years or less (n = 39), and 40 or more (n = 6)[1] were compared by analysis of variance. No significant differences between the two age groups were found, for either Anxiety at Work, $F(1,43) = .92$, n.s., or Trait Anxiety, $F(1,43) = .01$, n.s.

With the age groups amalgamated, the scores were compared with those published by Speilberger (1983): Anxiety at Work was compared with published state anxiety data, and Trait Anxiety with published trait anxiety data. As Table 3 shows, the mean values were similar, even though Anxiety at Work is not exactly the same as state anxiety, nor Trait Anxiety exactly the same as trait anxiety as defined by Speilberger. However, the standard deviations of Anxiety-at-Work scores were lower than those published for state anxiety.

Mean anxiety scores of men (n= 11) and women (n = 34) were also compared by analysis of variance, and again no significant differences were found for Anxiety at Work, $F(1,43) = .78$, n.s., or Trait Anxiety, $F(1,43) = 2.64$, n.s.

Because no significant differences were found between the males and females, or between the two age groups, the sample was considered to be homogeneous with respect to anxiety, and henceforth anxiety scores refer to the sample as a whole. Anxiety at Work and Trait Anxiety correlated, $r = .63, p < .001$. The scatter graph of these two variables (Figure 3) illustrates this relationship.

Footnote

[1]The published norms cover three groups: 19-39, 40-49, 50-69, but this sample included only 2 subjects over 49 years of age.

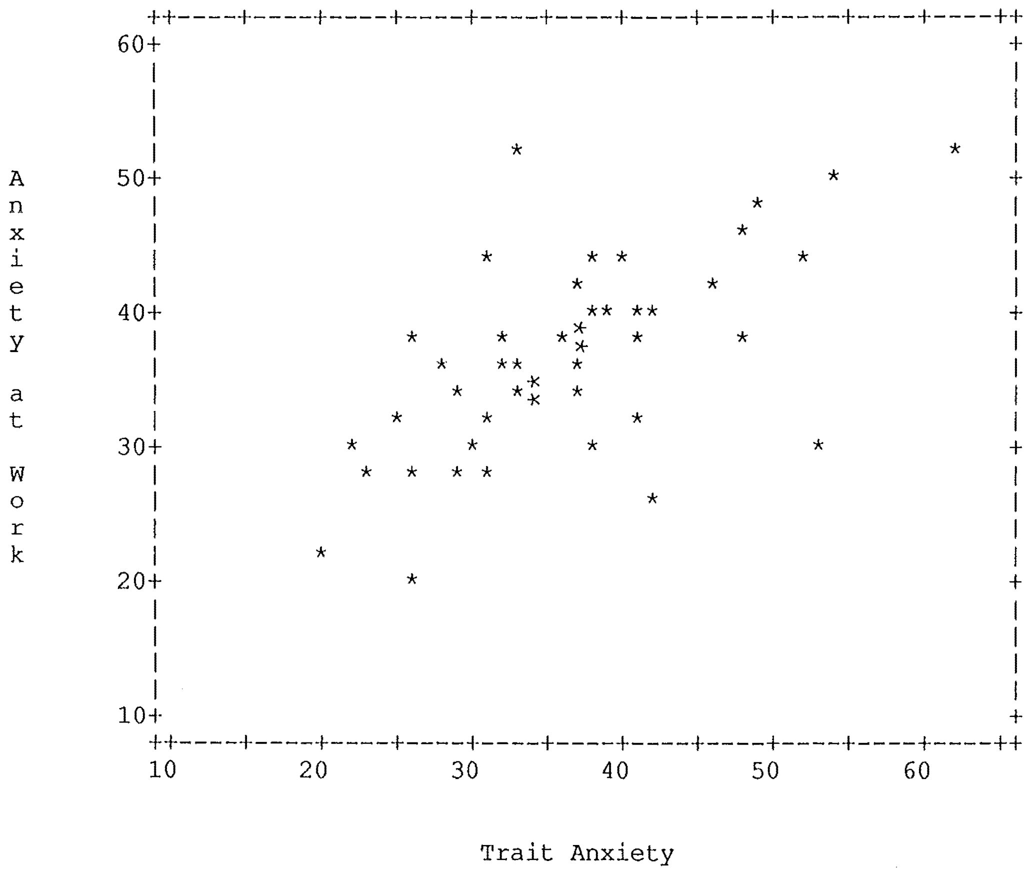


Figure 3. Scatter graph of Trait Anxiety against Anxiety at Work.

Table 3

Anxiety Scores with Published Norms

Group	*Mean*		*SD*		*Range*	*N*
			Anxiety at Work			
Males	34.5	(35.7)	7.5	(10.4)	22 - 48	11
Females	36.7	(35.2)	7.1	(10.6)	20 - 51	34
Total	36.2		7.2		20 - 51	45
			Trait Anxiety			
Males	32.7	(34.9)	8.1	(9.2)	20 - 49	11
Females	37.7	(34.8)	9.2	(9.2)	22 - 62	34
Total	36.5		9.1		20 - 62	45

Note. The greater the score, the greater the anxiety; possible range 20 - 80. Figures in brackets are those published by Speilberger (1983), rounded to one decimal place.

Muscle Tension

Electromyography scores are summarized in Table 4, after the description of each of the four variables measured.

Recovery Time (RT). There was a significant correlation between the early and the later Recovery Time readings: shoulder $r = .56$, arm $r = .50$, $p < .001$. Despite considerable variation, readings were higher by the end of the shift, for both arm and shoulder, by an average difference of 0.4 seconds. This represents a 14% increase for the shoulder, and a 21% increase for the arm. However, paired t-tests showed that these differences were not significant for the shoulder, $t(42) = 1.49$, n.s., or the arm, $t(42) = 1.12$, n.s. Therefore for most analyses, an average value of Recovery Time was used for the arm and for the shoulder.

Working Muscle Tension (WMT). As for Recovery Time, t tests showed that Working Muscle Tension was not significantly higher later in the shift for the shoulder, $t(44) = 1.34$, n.s., or the arm, $t(44) = .61$, n.s. The mean difference for the shoulder was 0.6μv, representing a 7% increase only in shoulder tension. For the arm, there was a 0.5μv, or 2%, decrease in arm tension. Again, early and later readings were strongly correlated: shoulder $r = .78$, arm $r = .91$, $p < .001$. Therefore for most analyses, an average value of Working Muscle Tension (i.e. from early and late in the shift) was used for the arm and for the shoulder.

As might be expected, there was a significant correlation between Working Muscle Tension and Recovery Time for the shoulder, $r = .47$, $p < .001$. However, there was no such relationship between Working Muscle Tension and Recovery Time for the arm, $r = -.12$, n.s.

Maximum Voluntary Contraction (MVC). The highest recorded value of Maximum Voluntary Contraction for each site, shoulder and forearm, was taken to be the MVC for that subject. There was considerable variation, as shown in Table 4. However, there was a significant correlation between MVC_{arm} and $MVC_{shoulder}$, $r = .52$, $p < .001$, suggesting that those subjects with stronger shoulders also had stronger forearm muscles. Subjects with higher MVC readings for the shoulder also tended to work with higher shoulder tension, $r = .51$, $p < .001$, and have higher Recovery Time, $r = .62$, $p < .001$.

However, these relationships did not hold for the arm.

Relative Working Muscle Tension (RWMT). This variable was derived by calculating Working Muscle Tension as a percentage of Maximum Voluntary Contraction. The Relative Working Muscle Tension ranged from less than 3%, a relatively safe working ratio[1], to more than 13% for the shoulder, and to almost 29% for the arm. For the shoulder, most subjects (86%) were working below 10% of MVC, and all were below 14% of MVC, as recommended by Bjorksten and Jonsson (1977, cited in Grieco et al., 1989). However, for the arm, exactly two thirds were working at a mean level higher than 10%, and 40% of subjects were working at mean levels higher than 14%.

Footnote

[1]Studies by Bjorksten and Jonsson (1977, cited in Grieco et al., 1989), on resistance to fatigue in exercises repeated for varying lengths of time, led to the definition of maximum limits of 10-14% of MVC for median loads. Beyond this 10-14% range, there is a marked drop in endurance due to restriction in muscle blood flow.

Table 4

Electromyography Results

Variable	*Mean*	*SD*	*Range*	*N*
		Shoulder		
WMT (μv)	9.1	4.7	2.8 - 24.6	47
MVC (μv)	156.5	83.6	53.0 - 485.0	42
RWMT (%)	6.5	3.1	2.1 - 13.1	42
RT (seconds)	2.3	1.9	0.0 - 9.5	46
		Arm		
WMT (μv)	28.4	12.6	12.1 - 70.6	47
MVC (μv)	257.2	110.9	88.0 - 543.0	42
RWMT (%)	13.1	6.4	2.7 - 28.9	42
RT (seconds)	3.2	1.8	1.4 - 11.0	47

Note. WMT = Working Muscle Tension; MVC = Maximum Voluntary Contraction; RT = recovery time;

RWMT = Relative Working Muscle Tension (i.e. WMT/MVC x 100).

Musculoskeletal Trouble

Table 5 shows results from the Questionnaire about Back and Arm Trouble.

Table 5

Percentage of Subjects Experiencing Musculoskeletal Trouble

Site	12-month prevalence	7-day prevalence	Activities prevented		Problems	
			At work	Away	Serious	Need attention
Neck	41.3	22.7	10.9	13.3	2.2	13.3
Shoulder	41.2	26.1	19.6	13.0	0.0	15.2
Elbow	26.6	8.9	17.8	14.0	0.0	6.7
Wrist/hand	63.0	20.5	26.6	16.3	4.5	11.4
Upper back	30.4	10.9	17.8	14.0	0.0	8.7
Lower back	29.8	14.9	14.9	11.1	2.2	6.5

As indices of musculoskeletal trouble, four variables were calculated for each subject. The scores obtained for all four variables, with and without the inclusion of back trouble, are shown in Table 6.

12-Month Troubles : the number of sites in which trouble was experienced at work during the last 12 months. Shoulders, hands and elbows could each count as one or two sites (e.g. one or two shoulders), giving a possible maximum of nine sites. The results are shown in Figure 4.

Recent Troubles : the number of sites in which trouble was experienced at work during the last 7 days. Again, shoulders, hands and elbows could each count as one or two sites. The results are shown in Figure 5.

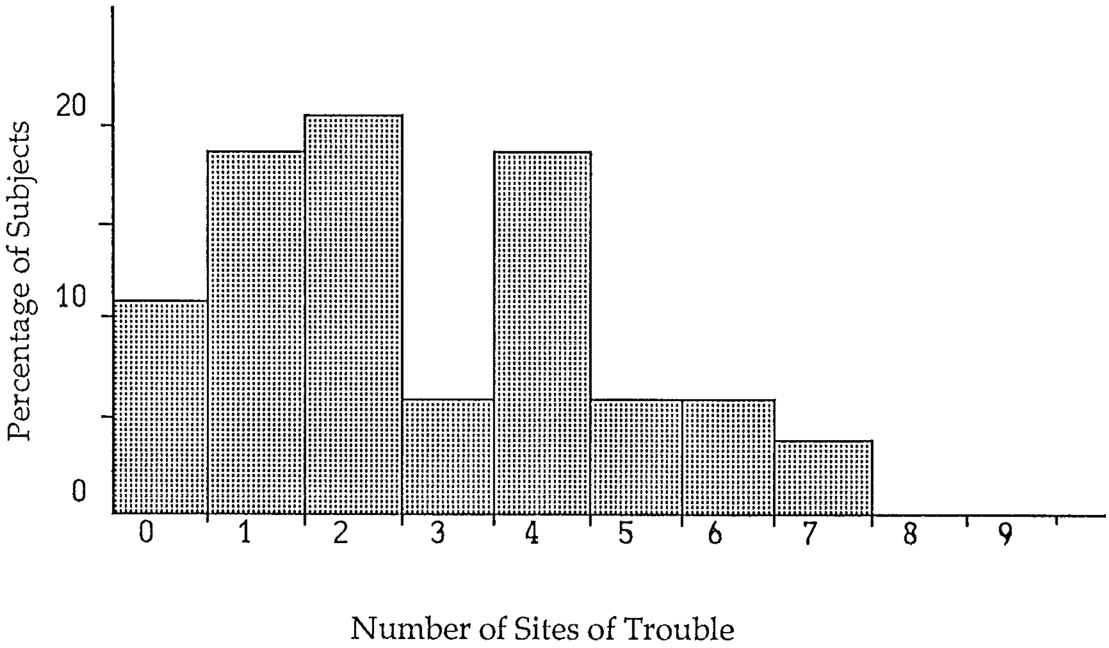


Figure 4. Number of sites of musculoskeletal trouble experienced at work during the previous 12 months.

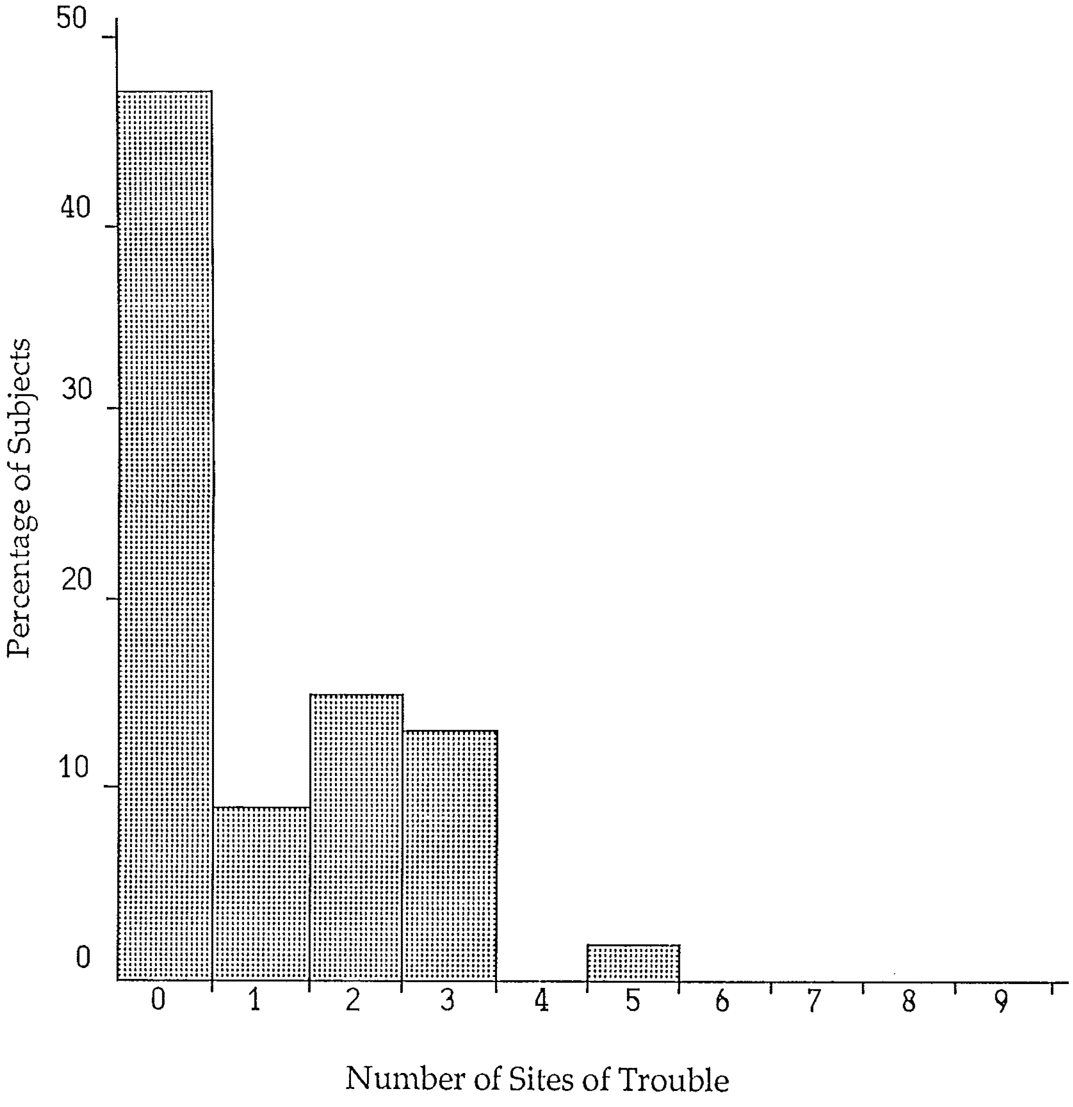


Figure 5. Number of sites of musculoskeletal trouble experienced at work during the previous 7 days.

Neck-Shoulder Trouble : calculated by adding questionnaire scores of Questions 10 - 13 for these sites (See Appendix G), with some scores recoded:

No trouble, or question not applicable	0
Trouble in the neck (Questions 10, 12)	1
Trouble in one shoulder (Qs. 10, 12)	1
Trouble in both shoulders (Qs. 10, 12)	2
Activities prevented at work (Q. 11a)	1
Activities prevented away from work (Q. 11b)	1
Not a real problem (Q. 13)	1
Problem needs attention (Q.13)	2
Problem serious (Q.13)	3

This gave a variable with a possible range of 0 - 13.

Arm Trouble : calculated in the same way as the index of neck and shoulder trouble, but using the scores for elbow trouble and wrist-hand trouble. The possible range was 0 - 14.

Table 6

Scores for Musculoskeletal Variables

Index	*Mean*	*SD*	*Range*	*N*
12-Month Troubles	2.8	2.0	0 - 7	44
12-Month Troubles excluding back	2.2	1.6	0 - 6	45
Recent Troubles	1.0	1.3	0 - 5	40
Recent Troubles excluding back	0.8	1.0	0 - 3	41
Neck-Shoulder Trouble	2.7	3.2	0 - 12	44
Arm Trouble	2.9	2.9	0 - 12	41

Table 7

Summary List of Variables

Concept	Variable	Measure
Job Stress		
	Strain	Pressure/Strain Questionnaire
	Stress	Sources of Job Stress questionnaire
Anxiety		
	Anxiety at Work	Self-Evaluation Questionnaire
	Trait Anxiety	
Muscle tension		
	Working Muscle Tension (WMT)	Electromyography
	Maximum Voluntary Contraction (MVC)	
	Relative Working Muscle Tension (RWMT i.e. WMT/MVCx100)	
	Recovery Time (RT)	
Musculoskeletal trouble		
	12-Month Troubles	Q. about Back and Arm Trouble
	Recent Troubles	
	Neck-Shoulder Trouble	
	Arm Trouble	

Intercorrelations Among the Variables

Table 8 shows significant intercorrelations among the job stress, anxiety and muscle tension variables, and Table 9 shows significant correlations of job stress, anxiety and muscle tension with the musculoskeletal trouble variables.

Table 8

Significant Intercorrelations Among Job Stress, Anxiety and Muscle Tension Variables

	Trait Anxiety	Anxiety at Work	$WMT_{arm, late}$	$RT_{arm, late}$	$WMT_{shoulder, late}$	$MVC_{shoulder}$	$RT_{shoulder, early}$	$RT_{shoulder, late - early}$	$RT_{shoulder}$
Strain	.37**	.34*							
Stress								-.45**	
Trait Anxiety		.63***							
$WMT_{arm, early}$			.91 ***						
MVC_{arm}						.52 ***			
$RT_{arm, early}$				.50 ***					
$WMT_{shoulder, early}$					.78 ***				
$WMT_{shoulder}$						.51 ***			.47 ***
$MVC_{shoulder}$									.62 ***
$RT_{shoulder, late}$							.56 ***		

Note. WMT = Working Muscle Tension; MVC = Maximum Voluntary Contraction; RWMT = Relative Working Muscle Tension (i.e.WMT/MVCx100); RT = recovery time.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 9

Significant Correlations of Job Stress, Anxiety, and Muscle Tension with Musculoskeletal Trouble Variables

	12-month Troubles	Recent Troubles	Neck-Shoulder Trouble	Arm Trouble
Strain			.32*	
Anxiety at Work				.37*
$MVC_{shoulder}$	-.31*	-.31*		
$RWMT_{shoulder}$	.31*			.30*

Note. MVC = Maximum Voluntary Contraction; RWMT = Relative Working Muscle Tension (i.e.WMT/MVCx100).

*$p < .05$.

Tests of the Hypotheses

Hypothesis 1. Because Strain and Stress did not correlate with one another, and neither was obviously a superior measure, both were compared with the anxiety variables. There was no significant correlation between Stress and either Anxiety at Work or Trait Anxiety, although 4 of the 17 individual dimensions of stress did correlate with Anxiety at Work, $.30 \leq r \geq .37$, $p <.05$. These dimensions were Underutilization, Role Ambiguity, Career Progress and Job Scope. There was a significant correlation between Strain and both Anxiety at Work, $r = .34$, $p < .05$, and Trait Anxiety, $r = .37$, $p < .01$. However, regression analysis showed that 39% of the variance of Anxiety at Work could be explained by Trait Anxiety, $F(1,43) = 28.01$, $p < .001$. Strain explained no further variance.

Therefore the data gave only limited support to Hypothesis 1.

Figure 6 shows the scatter graph of Strain against Anxiety at Work.

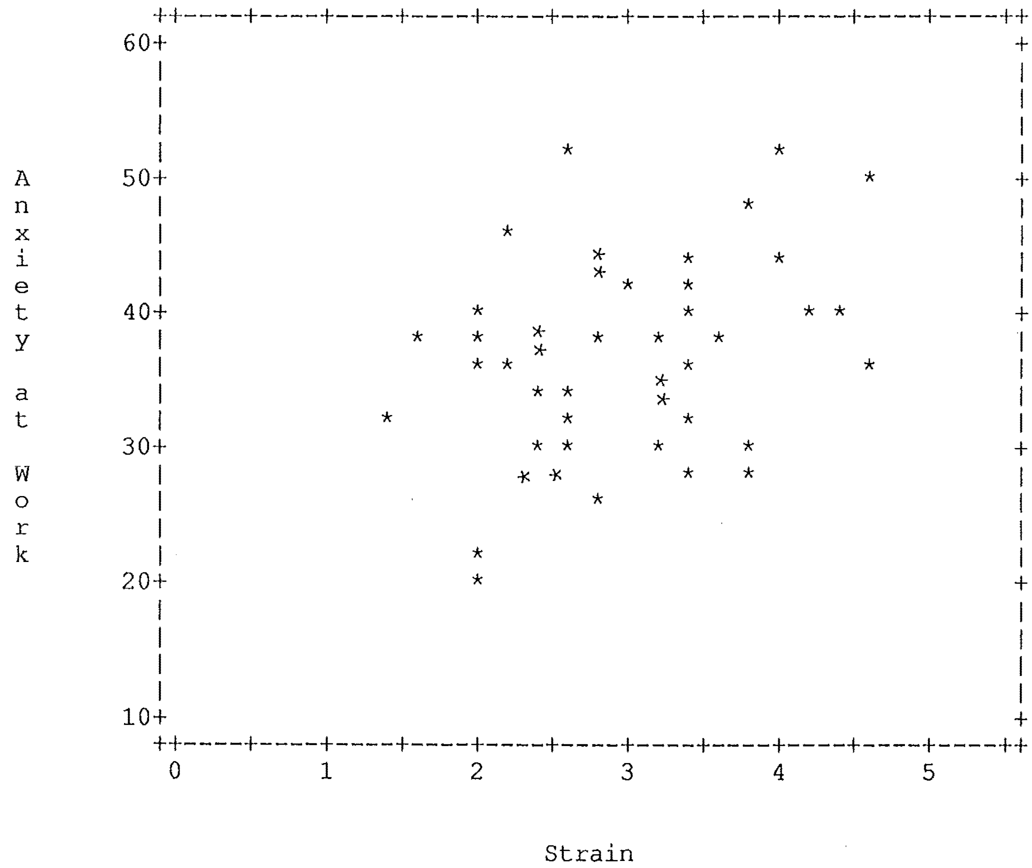


Figure 6. Scatter graph of Strain against Anxiety at Work.

Hypothesis 2. There was no significant statistical relationship between the job stress variables and Working Muscle Tension or between the anxiety variables and Working Muscle Tension. This means that the data gave no support to Hypothesis 2.

Hypothesis 3. The number of subjects with marked musculoskeletal problems was fairly small, but the data did suggest some of the expected links between muscle tension and musculoskeletal trouble, giving partial support to Hypothesis 3. In particular, Relative Working Muscle Tension of the shoulder was significantly correlated with Arm Trouble, $r = .31$, $p < .05$, and also with 12-Month Troubles. This latter relationship held whether back trouble was included, $r = .31$, $p < .05$, or excluded, $r = .34$, $p < .05$. Maximum Voluntary Contraction of the shoulder was negatively related to 12-Month Troubles and Recent Troubles. For both relationships, $r = -.31$, $p < .05$.

Despite the unexpected lack of correlation between psychological variables and muscle tension, there were two significant relationships between psychological variables and musculoskeletal trouble:

1. Anxiety at Work correlated with Arm Trouble, $r = .37$, $p < .05$. Regression analysis of Arm Trouble showed that Relative Working Muscle Tension of the shoulder and Anxiety at Work, the two variables which correlated with Arm Trouble, together accounted for 25% of the variance, $F(2,33) = 5.38$, $p < .01$. Anxiety at Work was the more important of the two independent variables, $B_{\text{Anxiety at Work}} = .36$, $B_{\text{RWMTarm}} = .28$.

2. Strain and Neck-Shoulder Trouble correlated positively, $r = .32$, $p < .05$.

Hypothesis 4. Finally, looking at the Recovery Time data, there was no significant correlation between job stress or anxiety variables and Recovery Time for the arm. However, there was a significant positive correlation between Stress and Recovery Time for the shoulder early in the shift, $r = .31$, $p < .05$, until two outlying cases were excluded, when the correlation became non-significant, $r = .11$, n.s. Later in the shift the correlation was also non-significant, but negative. Consequently, the expected increase in Recovery Time associated with perceived stress (Hypothesis 4), was not found. To the contrary, there was an unexpected strong negative correlation, $r = -.45$, $p < .01$, between Stress and increase in Recovery Time for the shoulder over the shift ($RT_{shoulder,\ late\ -\ early}$), disconfirming Hypothesis 4. Figure 7 shows the scatter graph of this relationship.

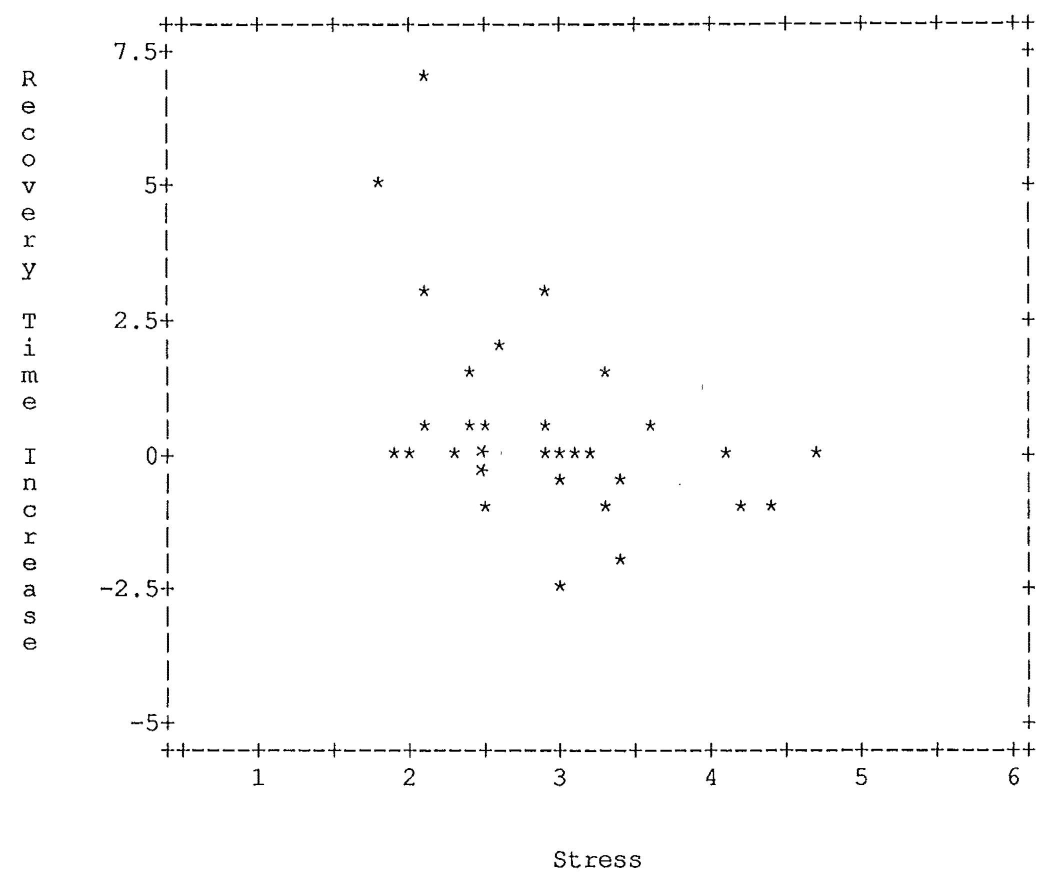
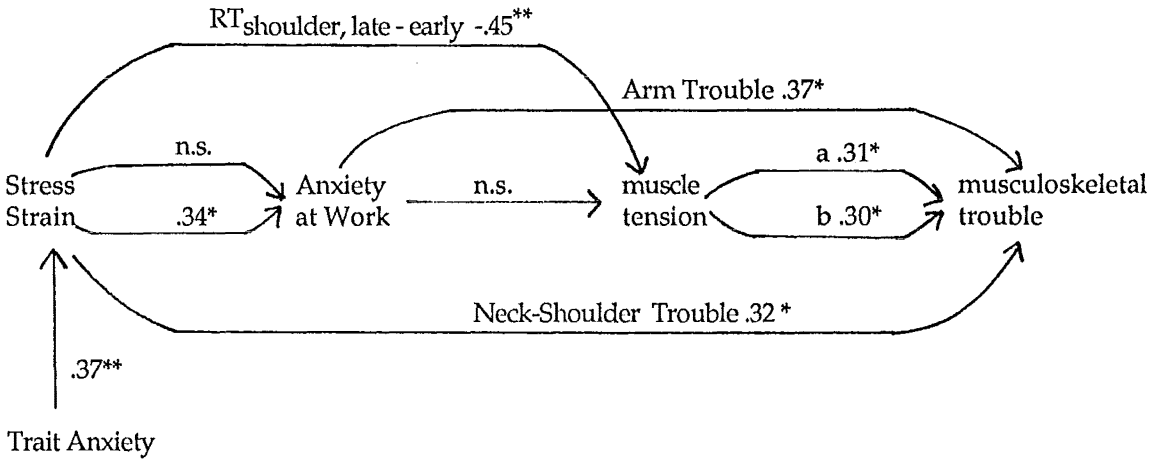


Figure 7. Scatter graph of Stress against increase in Recovery Time of the shoulder over the shift.

Figure 8 summarizes significant correlations relevant to the hypotheses.



[a] Relative Working Muscle Tension of the shoulder/ 12-Month Troubles.

[b] Relative Working Muscle Tension of the shoulder/ Arm Trouble.

$^{*}p < .05$. $^{**}p < .01$. n.s. = not significant.

Figure 8. Summary of results.

Causal Attribution

Subjects were asked, "What do you think is the cause of your trouble?" Thirty respondents suggested causes for their problems, with 52 suggestions being given altogether. Of these, exactly half were concerned with posture and workstyle, or the nature of the work. For example,

"Just the way I sit"

"The way I perhaps hold my wrists" [*sic*]

"Keyboard work"

"New technique".

A further 9 (17%) were to do with static load, including,

"Concentration in a fixed position"

"Long hours sitting at a workstation".

Five suggested causes (10%) were concerned with previous injuries aggravated by work:

"Back injury when I was 12".

There were four comments (8%) about ergonomic aspects of the workplace:

"Filing for long periods bent over"

"Angle of the keyboard"

"Keyboard weighted for right hand functions" (left-hander),

and four (8%) about non-work activities, such as,

"Could be due to aerobics".

Two people mentioned tension, one pregnancy, and one the weather.

Preventative Behaviour

Subjects were also asked to indicate which of six behaviours they practised to make themselves more comfortable at the keyboard. Every subject indicated at least one of these behaviours, and 28 (60%) indicated three or more. Adjusting the workstation was the most frequently indicated preventative measure, with 70% of subjects doing this. Only about half reported taking short or longer rest breaks. Anecdotal evidence suggested that even when entitled to take such breaks, many workers preferred to get on with their work, or felt pressured by the work which needed to be done. The least frequently used preventative measure was exercises at work to release tension. Only 30% reported doing such exercises, even though in one workplace exercise periods were organized at regular intervals during the day. Table 10 shows how many subjects indicated that they practised the six measures suggested.

Table 10

Subjects Practising Preventative Behaviours

Behaviour	*n*	%
Adjusting the workstation	33	70
Occasional long breaks (e.g. 10 mins/hr)	25	53
Frequent short breaks	23	49
Exercise or sport to keep fit	22	47
Changing the activity	19	40
Exercises at work to release tension	15	32

Discussion

The results of this study give limited support to two of the four hypotheses:

Hypothesis 1, that *greater perceived job stress will be reflected in greater anxiety at work of keyboard operators,* is partly supported as measured with the short, Pressure/Strain Questionnaire, but not with the longer, Sources of Job Stress questionnaire. However, anxiety at work may equally well be the consequence of trait anxiety.

Hypothesis 2, that *higher levels of perceived job stress and anxiety at work will be reflected in greater muscle tension of the shoulders or forearms of keyboard operators, as measured by electromyography,* is not supported. The data do not show any links between anxiety or job stress and either muscle tension of the shoulder or forearm as a subject works or the time taken to relax after keying.

Hypothesis 3, that *greater job stress, anxiety at work and muscle tension of the shoulders or forearms will be associated with more prevalent and/or more serious musculoskeletal complaints of the shoulders, neck, arms and back of keyboard operators,* is supported: job stress as measured with the Pressure/Strain Questionnaire correlates with reported neck and shoulder trouble; anxiety at work correlates with reported arm trouble; and working muscle tension of the shoulder as a percentage of maximum voluntary contraction correlates with reported musculoskeletal trouble at work during the last 12 months, and with reported arm trouble.

Hypothesis 4, that *keyboard operators who perceive higher levels of job stress will take longer to relax at the end of the working day than at the beginning,* is not supported. In fact, the reverse appears to be true.

Despite the significant correlations, many of the variables that could be expected to correlate do not. There are a number of possible reasons for this:

1. The model may be faulty, but in that case the significant correlations in the data would be unlikely.

2. Other factors may override real associations between stress or anxiety and muscle tension. For example a workstation that has not been adjusted for the operator, or that is suboptimal for the kind of work, may cause extra tension irrespective of psychological factors; or operators may have awkward work habits of which they are unaware.

3. Limitations of the measures. Each of the measures will be discussed.

Job stress questionnaires. The questionnaire, Sources of Job Stress (Stress Diagnostic Survey) directs respondents to focus on the frequency of occurrence of various causes of stress at work, and so probably gives a more precise measure of actual stress than than the Pressure/Strain Questionnaire. It is, therefore, disappointing that scores do not correlate with any measures apart from the difference in the time taken to relax the shoulder early and later in the shift. The administration of this questionnaire could possibly be improved by verbally emphasizing "to you" in the instruction to indicate the frequency with which each condition is a source of stress to the respondent; a subject may be aware of many potential sources of stress in the work environment, without being worried by these. It is impossible to tell whether subjects followed the instructions correctly, or whether they overlooked this personal emphasis. However the similarity of scores with those of the United States norms provided by the authors, suggests that the subjects did much as expected.

As well as norms, Ivancevich and Matteson (1988) provide internal consistency and test-retest reliability data for the Stress Diagnostic Survey; they conclude that the inventory possesses acceptable construct and face validity, internal consistency, and reliability, for diagnostic and research purposes. There is no comparable data for the Pressure/Strain Questionnaire, but this short questionnaire has good face validity and scores do correlate significantly with neck and shoulder trouble.

On the whole, subjects of this study report only low to moderate levels of stress. Perhaps if more people under high stress had been included, more significant relationships between job stress and the other variables would have been apparent.

Self-Evaluation Questionnaire. To comply with instructions by Speilberger (1983) for the use of the state anxiety scale, a specific time frame would normally be added. In the context of this study, situation-specific (i.e. at work) anxiety was of interest. However if I were to repeat the field work, I might possibly change the instructions to, "Thinking about yourself at work during the last week, describe how you generally felt", rather than, "Describe how you generally feel at work". As it happened, the distribution of results so closely resembles those published by Speilberger, that perhaps it does not matter.

The high correlation between Anxiety at Work (state anxiety) and Trait Anxiety is of interest, because trait anxiety is not normally predictive of state anxiety except under conditions which threaten self-esteem (Speilberger, 1983). The workplace may well have this quality.

The lack of correlation between Anxiety at Work and Stress, coupled with the high correlation of Anxiety at Work with Trait Anxiety, suggests that anxiety at work may be more a reflection of the person than of job stress. On the other hand, there is a modest correlation of Strain with Anxiety at Work. The most likely explanation (given poor correlation between Anxiety at Work and Stress) is that feelings of pressure, strain and anxiety are related in a phenomenal sense--all negative feelings--rather than because of any causal relationship.

Questionnaire about Back and Arm Trouble. This questionnaire fulfilled the aim of providing a measure of the presence or absence of musculoskeletal trouble at work over the last 12 months, and some indication of the seriousness of the trouble. Early in the study, missing data in this particular questionnaire alone suggested that it was more difficult to complete than the others. For the rest of the study, checking at the time of collection resolved the problem. Because of this difficulty, the questionnaire would not be useful for group administration, except, perhaps, with very careful verbal instructions to supplement the written instructions.

Electromyography. Recovery Time was chosen as a dependent variable in the sequence, stressful work environments creating anxiety, leading to bracing of muscles, because it was expected to be relatively unaffected by the workstation, the nature of the work and idiosyncratic work habits. On the other hand, Working Muscle Tension and Relative Working Muscle Tension, reflect all of these but are more logical independent variables in the sequence, bracing of muscles leading to pain.

The data from electromyography appear to be reliable measures of muscle activity on the day of measurement, as shown by the high correlation and non-significant differences between repeated measures of Working Muscle Tension. These results are consistent with the findings of Hagberg and Sundelin (1986) who measured muscular load and found that the EMG levels of the trapezius muscles of their word processor operators were fairly constant through a 5-hour work period. Hagberg and Sundelin also found no significant differences between the right and left trapezius muscles of their subjects. In the present study, measurement was limited to the right hand side for practical reasons, and because there was no reason to believe the left hand side would give higher EMG readings. However this is an assumption, because even when the left hand is not used for keying, it is often used for handling documents.

The differences between repeated measures of Recovery Time are also non-significant. The moderate correlation between these Recovery Time measurements, lower than that for Working Muscle Tension, is not surprising, because there is greater likelihood of measurement error. The time it takes for a person to relax the working muscles as in this study, is generally short, and so a small hesitation on the part of the operator could make a significant difference to the time recorded. Also, it is possible for an operator to anticipate the command and so decrease the recorded time.

Rather than increasing during the day because of fatigue, anxiety and stress, the data suggest that the time taken for the muscles to relax varies from person to person, and may be characteristic of the person. During the data collection period it was clear that most operators do not deliberately rest their arms and shoulders at the keyboard, even when pauses are a natural feature of the work, such as in subediting. However, it is reasonably easy to teach people to do this, as required in the study.

One needs to consider whether this outcome measure (Recovery Time) is clearly related to the variables with which the investigation is concerned, that is muscle tension. For the shoulder, there clearly is the expected relationship, with a correlation of just under .5 between Working Muscle Tension and Recovery Time. There is no such relationship for the arm. However, for both shoulder and arm, Recovery Time can be considered to be a separate variable with its own implications for musculoskeletal comfort and health. The choice of this variable is affirmed by the significant negative correlation between Stress and differences in Recovery Time measured early in the shift and later. I have no explanation for this negative correlation, the opposite to that which was expected, but such a definite correlation does suggest that Recovery Time may be a variable to explore. The lack of any correlation between Recovery Time and anxiety may be explained by experimenter effects--the novelty of the procedure might overwhelm the effects of the psychological variable. On the other hand, it may be that the measurement technique of either variable is not sufficiently sensitive to pick up any correlations. A third possibility is that Recovery Time is simply not related to anxiety. From the results of this study, there is no evidence to suggest that it is.

Finally, the measurement of Maximum Voluntary Contraction is a little imprecise, even though it was carried out carefully. There are two drawbacks:

1. Ideally this measure should have been repeated twice more, to give the highest of three readings. However it seemed to discomfort or tire some subjects, and is not recommended for people who already suffer from musculoskeletal trouble. Therefore only one measurement each was taken for the arm and for the shoulder, early and late in the shift, as a compromise to maintain the well-being and goodwill of the subjects.

2. The calculation of EMG as a percentage of MVC assumes that force applied to the task is linearly related to EMG. Therefore if possible, muscle strength should be measured independently of EMG measurement, for example as described by Sundelin and Hagberg (1989) for the shoulder, using a strain gauge dynamometer connected to a sling over the shoulder. Then the EMG readings are calibrated against actual percentages of MVC, as calculated from the dynamometer readings. However, methods similar to those used in the present study do have precedents in the literature, as in a recent study of muscular effort and musculoskeletal disorders in piano students by Grieco et al. (1989).

Theoretical Significance of the Results

The contribution of this study lies in its partial validation of a plausible model of causation of a perplexing workplace problem. The data give some empirical support to Wright's (1987) model of causation of pain at work, because they show clearly that job stress, anxiety, muscle tension and musculoskeletal problems are connected. However these factors are not necessarily directly linked in the way the model indicates. In particular, the link between anxiety and arm problems, apparently without increased working muscle tension as measured in the study, gives some support to those who hold the view of a psychological basis of overuse injuries (e.g. Lucire, 1986).

Practical Implications of the Research

This research has practical implications for both keyboard operators and employers. First, the model upon which the work is based is easily understood, and should be acceptable to different parties in the controversy about occupational overuse injuries. It is comprehensive and, taken as a whole, does not place blame on any party. Also, the model gives some clues as to useful points of intervention for the prevention of overuse injuries.

A second implication concerns micropauses, pauses of a few seconds which occur spontaneously and frequently in response to the fatiguing effects of continuous work (Grandjean, 1979). These short breaks allow the working muscles to relax, improving circulation in otherwise tight muscles, and include both rest pauses and diversionary pauses which change the pattern of activity. Sundelin and Hagberg (1989) observed rest pauses among VDU operators and found a significant negative correlation between the number of spontaneous pauses and static muscular load. Hagberg and Sundelin (1986), studying VDU wordprocessor operators, found that rated discomfort was was less after work periods with 15-second pauses every 6th minute, than after work periods without. Henning, Sauter, Salvendy, and Krieg (1989) found that frequent micropauses of discretionary length were beneficial in reducing fatigue and associated performance decrements among keyboard operators working on a data entry task, but that subjects tended to terminate the micropauses before complete recovery could occur.

In the present study, the procedure for measuring Recovery Time was a requested micropause. Two points could be noted:

1. As the data show, the time it takes for muscles to relax completely varies considerably from person to person. Although most people achieve arm and shoulder relaxation in 5 seconds or less, for some the time required may be 10 or 11 seconds. For these people, a micropause will need to be at least this long.

2. Although complete relaxation is not difficult to teach, itias clearly not a normal practice for most subjects. Therefore VDU operators are either unaware of the value of short pauses, or their natural resistance to pausing in the middle of a task is greater than the perceived value of such breaks. Hagberg and Sundelin (1986) comment that the introduced pauses in their study were regarded as distubing to work routines.

Finally, the correlation between Relative Working Muscle Tension of the shoulder and rated musculoskeletal problems is important. Keyboard operators are advised to work in a relaxed way, but they could also lower relative muscle tension by increasing Maximum Voluntary Contraction. That is, strengthening the shoulders should lead to a reduction in musculoskeletal problems in some people, despite their working muscle tension. Cook (1988) describes a successful management plan for overcoming occupational overuse symptoms of VDU operators and clerical workers, based upon graduated exercise programmes. The concept applied is to build the strength in the muscles so that their functional contractile power is superior to the external forces applied to these muscles. However, in the present study, less than half of the subjects exercise or play sport to keep fit, and those who do may or may not benefit by strengthening of the arms or shoulders.

Limitations of the Research

The three methodological drawbacks of this study are (a) the voluntary nature of the sample, (b) the cross-sectional nature of the procedure, and (c) the non-interventionist approach. With respect to the sample, the selection of workplaces seems satisfactory: some employees at all the workplaces involved had experienced overuse problems, and the workplaces and the work done encompassed considerable variety. Within the organisations, there was no way of telling whether or not volunteers differed in any relevant ways from non-volunteers, but there was no good reason to suspect differences. Workers under high stress may have been reluctant to undertake the additional work and disruption required by the project; on the other hand, they may have been willing to participate in a project from which they might benefit. (Other operators naturally excluded would be those who had quit their jobs because of overuse or stress problems.) At two of the five workplaces, and in one department of a third, all current full-time operators participated. That is, 20 of the 47 subjects were the result of 100% sampling in three offices.

However, the subjects were never intended to be representative of all keyboard operators. Rather the intention was to see whether the sequence, job stress creating anxiety, leading to bracing of muscles, leading to pain, could be demonstrated at all. As job stress and anxiety were not shown to lead to the bracing of muscles of keyboard operators in this study, the problem of generalizability is really not important here. It is likely, however, that anxiety, feelings of pressure, and the bracing of muscles are associated with musculoskeletal trouble in many situations.

The cross-sectional nature of the study is a more serious drawback. The significant correlations between variables do not necessarily demonstrate the cause and effect sequences suggested by the model. It is as plausible that pain at work creates anxiety and muscle tension as the reverse. If it had been possible to repeat the procedure at different times of the year when stressors were likely to be greater or less, then more conclusive results might have been obtained. However, to do so would have been beyond the scope of this project. Even if the participating organisations and subjects had been willing, a considerably larger initial sample would have been needed to ensure enough subjects at follow-up, given the current climate of economic uncertainty and frequent restructuring of organisations. Instead, taking repeated EMG measures during a single shift was an attempt to obtain valid data to test the hypotheses.

The non-interventionist approach was a deliberate policy not to interfere in the workplace, but rather to assess the situation just as it is. However, it is possible that at least some subjects would benefit by being shown (a) how to adjust their workstations and (b) how minor changes to workstyle and habits can make a considerable difference to strain on the body. Although 70% of subjects do adjust their workstations, many do not, and only about half or less are using each of the other five preventative behaviours mentioned in the Questionnaire about Back and Arm Trouble. Perhaps if an educational intervention had been carried out first (i.e. training in relaxed work methods and workstation adjustment), the expected relationships between variables might have been demonstrated more definitively. Subjects were, of course, trained in the micropause procedure, and this appeared to be satisfactory.

Future Directions

The scope of this project was fairly broad, and therefore perhaps rather superficial. Future research could focus on specific parts of the behaviour sequence, using an experimental approach. For example, after initial training in workstation adjustment and relaxed work style (i.e. dealing with physical causes of tension first), anxiety could be manipulated in a way that would simulate job conditions, and muscle tension could be measured. The data of this study suggest that the time of day may not matter in the collection of EMG data. Shoulder measurements appear to be more useful than arm measurements, perhaps because stress is more likely to affect the trapezius muscle than arm muscles, or perhaps because arm muscle activity is more affected by the work, workstation and habit. Individual differences in reactivity also need to be considered; Westgaard & Bjørklund (1987), for example, report considerable inter-individual variability in muscular response to stress. Finally, a longitudinal design could result in more convincing cause-and-effect data, especially if a more comprehensive analysis of musculoskeletal problems is included.

Conclusions

The strongest conclusion that one can draw from this study is that causation of musculoskeletal problems amongst keyboard operators is complex, probably a combination of many factors interacting with individuals. However, it is encouraging that links can be demonstrated between factors suspected of contributing to the problem of pain at work in such a small-scale study as this, even without the controls which could have been exerted in a laboratory study.

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Appendix A. Research proposal sent to participating organisations.

RESEARCH PROPOSAL FOR MSc THESIS

RESEARCHER: Gaylia Powell
90A Bryndwr Rd.,
Christchurch, 5.
Phone 351-6098 (after 3.30PM)
or 667-001 ext. 7194

SUPERVISOR: Dr Dean Owen
Dept. of Psychology,
University of Canterbury.
Phone 667-001 ext. 7966

TITLE OF PROJECT: Job stress, muscle tension and musculoskeletal discomfort of keyboard operators

PURPOSE:
This project was initiated in response to current concern about occupational overuse injuries. I believe that the research may add usefully to existing knowledge about the development and prevention of arm, hand and shoulder pain of some keyboard operators. In particular, I am interested in muscle tension and discomfort as a response to perceived job stress. If this can be shown, then it will provide theoretical validation of an individual approach to prevention using EMG biofeedback.

PARTICIPANTS: Men and women who work at keyboards for at least six hours per day. Their workstations must meet Dept. of Labour Code of Practice standards. On any one day, only three or four people can participate. However I would like between three and fifteen volunteers from any one workplace, ie from one to four days' work.

BRIEF DESCRIPTION OF THE PROJECT:
Participants will be asked to complete three questionnaires: a self-evaluation questionnaire , a questionnaire about job stress, and one about musculoskeletal discomfort. During the first half of the morning, and again during the latter half of the afternoon, muscle activity measurements of the forearm and shoulder will be taken from these people as they work and stop working. For this, I will use an electromyography (EMG) device borrowed from the Accident Compensation Commission, and the participants will continue with their usual work at their own workstations.

TIME INVOLVED: Each participant will need to spend about 15 minutes on questionnaire completion, plus an additional 20 minutes if work allows. Electromyography will involve each participant for about 20 minutes as he/she works, one morning and afternoon.

CONCEALMENT AND RISKS: None anticipated.

FEEDBACK:
I will be pleased to return to talk about the findings of the study and/or provide a written summary towards the end of the year, when data collection and analysis have been completed. If individual participants would like feedback on their own muscle activity measures, I could give them this information when I have finished collecting the data. I have found such feedback to be of considerable interest to those on whom I have tried the electromyography device, especially those who have musculoskeletal problems.

Appendix B. Letter to participants.

SURVEY OF JOB STRESS AND MUSCLE ACTIVITY

LETTER TO PARTICIPANTS

The purpose of this project is to study job stress and some of the effects of this on people who do sustained work at keyboards. The survey is part of a Masters thesis that I am doing at the University of Canterbury. The project has the approval of your Union and also the Health and Safety Coordinator of the NZ Council of Trade Unions.

On _______________ during the first half of the morning, and again during the latter half of the afternoon, I would like to take muscle activity measurements of your right forearm and shoulder as you work and stop working. For this, I will use a Muscle Biofeedback Monitor, and you will continue with your own work at your own workstation. The procedure is completely harmless and is often used by physiotherapists. It will take about 20 minutes morning and afternoon.

For these measurements, it is important that you wear clothing that is loose about the neck and forearms, and preferably does not have shoulder pads. A knit top or T shirt would be ideal, but a blouse or shirt which can be opened at the neck would also be suitable.

I would also like you to complete three questionnaires: a job stress inventory, a self-evaluation questionnaire and one about musculoskeletal discomfort. Altogether the questionnaires take, at most, 30 - 40 minutes, and should be completed while you are at work.

All the information you provide will be kept strictly confidential. I will not be recording your name on the questionnaires or data sheet. The data is being gathered from many people in a number of different workplaces, and a report of the overall results will be available when the project has been completed.

Participation in this project is entirely voluntary, and if you change your mind you may withdraw. However, I hope you will find the procedure interesting. I am very grateful for your help.

Gaylia Powell

Gaylia Powell

Appendix C.

Col 1 |_|_|_|2|

PRESSURE/STRAIN QUESTIONNAIRE

How to answer the questionnaire:

As individuals we differ in the way we respond to various situations and conditions. This questionnaire is designed to provide information about one form of response, that is job stress. There are no "right" or "wrong" answers. The best answer to each item is the one that *most nearly describes the way you really feel.*

Circle **1** if you ***strongly agree*** with the statement.
Circle **2** if you ***agree*** with the statement.
Circle **3** if you ***neither agree nor disagree*** with the statement.
Circle **4** if you ***disagree*** with the statement.
Circle **5** if you ***strongly disagree*** with the statement.

For the purposes of this questionnaire, **stress** is defined as existing whenever you experience **feelings of pressure, strain or emotional upset at work.**

		strongly agree	agree	neither agree nor disagree	disagree	strongly disagree	
1	Work often stretches me to the very limits of my capacity.	5	4	3	2	1	Col 5
2	Work stays with me so that I am thinking about it after hours.	5	4	3	2	1	
3	I am currently experiencing a lot of stress at work	5	4	3	2	1	
4	I am experiencing more stress at work this year than I did last year.	5	4	3	2	1	
5	I have felt more frustrated at work this year than I did last year.	5	4	3	2	1	Col 9

Thank you.

Appendix D.

(Optional Questionnaire)

SOURCES OF JOB STRESS

INSTRUCTIONS: For each item in this section of the survey you are asked to indicate the frequency with which the condition the item describes is a source of stress to you. Some items may describe conditions which are never a source of stress; others will describe conditions which are the source of varying amounts of stress. Simply circle the appropriate number (1 – 7) for each item that best describes how frequently each item is a source of workplace stress:

Circle 1 if the condition described is *never* a source of stress;

Circle 2 if it is *rarely* a source of stress;

Circle 3 if it is *occasionally* a source of stress;

Circle 4 if it is *sometimes* a source of stress;

Circle 5 if it is *often* a source of stress;

Circle 6 if it is *usually* a source of stress;

Circle 7 if it is *always* a source of stress.

Col 1 7

SOURCES OF JOB STRESS

THE EXTENT TO WHICH:		Never	Rarely	Occasionally	Sometimes	Often	Usually	Always	
1.	People tend to take credit for someone else's work achievements.	1	2	3	4	5	6	7	Col 5
2.	As job openings occur, available candidates from within the organization are not properly trained to fill them.	1	2	3	4	5	6	7	
3.	Promotions are not based on performance.	1	2	3	4	5	6	7	
4.	People working here do not have the opportunity to participate in making significant decisions.	1	2	3	4	5	6	7	
5.	Employees are not able to use their full skills and abilities while doing the job.	1	2	3	4	5	6	7	
6.	Supervisors do not go to bat for their subordinates with their superiors.	1	2	3	4	5	6	7	
7.	The formal policies employees are expected to follow are too restrictive.	1	2	3	4	5	6	7	
8.	My work unit is in a "firefighting" mode.	1	2	3	4	5	6	7	
9.	There is a tendency to exchange favors with people of higher rank in the organization.	1	2	3	4	5	6	7	
10.	The organization has no sound program to attract needed and capable people.	1	2	3	4	5	6	7	
11.	There does not seem to be a clear relationship between job performance and rewards.	1	2	3	4	5	6	7	
12.	Opinions of employees about the job are not listened to by management.	1	2	3	4	5	6	7	
13.	Job assignments are not challenging.	1	2	3	4	5	6	7	
14.	Supervisors are not concerned about the personal welfare of their subordinates.	1	2	3	4	5	6	7	
15.	The chain of command around here is not clearly understood.	1	2	3	4	5	6	7	
16.	There is too much paperwork in my work unit.	1	2	3	4	5	6	7	
17.	There is a lot of game playing on the part of employees trying to obtain power and authority.	1	2	3	4	5	6	7	
18.	Our organization makes no real attempt to keep good people.	1	2	3	4	5	6	7	
19.	People are not rewarded on the basis of solid performance.	1	2	3	4	5	6	7	
20.	Employees have no influence over how to do their jobs.	1	2	3	4	5	6	7	
21.	Job assignments in this organization do not make use of the talents of the employee.	1	2	3	4	5	6	7	Col 25

	THE EXTENT TO WHICH:	Never	Rarely	Occasionally	Sometimes	Often	Usually	Always	
22.	Supervisors show a lack of trust in their subordinates.	1	2	3	4	5	6	7	Col 26
23.	The way my work unit fits in with others in the overall plan is confusing.	1	2	3	4	5	6	7	
24.	There is too much duplication of effort in this organization.	1	2	3	4	5	6	7	
25.	One way to get ahead around here is to know the right person.	1	2	3	4	5	6	7	
26.	The organization does not make an effort to develop people to handle more authority and responsibility.	1	2	3	4	5	6	7	
27.	The rewards for working here are not handed out fairly.	1	2	3	4	5	6	7	
28.	Employees are only asked to participate in making trivial decisions.	1	2	3	4	5	6	7	
29.	Employees feel like they are not as involved in their work as they should be.	1	2	3	4	5	6	7	
30.	Supervisors do not show enough respect for their subordinates.	1	2	3	4	5	6	7	
31.	The way this organization is set up (organized) is too impersonal.	1	2	3	4	5	6	7	
32.	There is too much "red tape" in this organization.	1	2	3	4	5	6	7	
33.	The goals and objectives for my job are not clear.	1	2	3	4	5	6	7	
34.	I am asked to do a lot of unnecessary projects.	1	2	3	4	5	6	7	
35.	I have to take work home to stay caught up.	1	2	3	4	5	6	7	
36.	The work quality standards here are unrealistic.	1	2	3	4	5	6	7	
37.	There are insufficient opportunities for advancement in this organization.	1	2	3	4	5	6	7	
38.	I am held too accountable for the work of my co-workers.	1	2	3	4	5	6	7	
39.	The time deadlines for completing work assignments are too unreasonable.	1	2	3	4	5	6	7	
40.	The jobs I am assigned are just not important.	1	2	3	4	5	6	7	
41.	I lack the necessary automated technology and equipment to do my job.	1	2	3	4	5	6	7	
42.	It is not clear to me what my job responsibilities are.	1	2	3	4	5	6	7	
43.	I seem to receive conflicting requests from different people, (e.g., co-workers, bosses).	1	2	3	4	5	6	7	
44.	I spend too much time in unimportant meetings which take me away from my work.	1	2	3	4	5	6	7	
45.	My assigned tasks are too difficult for me to do.	1	2	3	4	5	6	7	Col 49

THE EXTENT TO WHICH:		Never	Rarely	Occasionally	Sometimes	Often	Usually	Always	
46.	I do not have the opportunity to develop myself for the future.	1	2	3	4	5	6	7	Col 50
47.	I am expected to be a source of help for too many people.	1	2	3	4	5	6	7	
48.	I have to rush in order to complete my job.	1	2	3	4	5	6	7	
49.	I do not receive enough feedback on how well I am doing my work.	1	2	3	4	5	6	7	
50.	My office layout is not proper for the work I do.	1	2	3	4	5	6	7	
51.	I am not sure of exactly what is expected of me.	1	2	3	4	5	6	7	
52.	I do things on the job that are accepted by one person and rejected by another person.	1	2	3	4	5	6	7	
53.	I am responsible for too many different activities.	1	2	3	4	5	6	7	
54.	I am asked to do things that I have not been trained to do.	1	2	3	4	5	6	7	
55.	I am hurting my career progress by staying in my job.	1	2	3	4	5	6	7	
56.	I am too responsible for providing needed information to others.	1	2	3	4	5	6	7	
57.	There is just not enough time to do my work.	1	2	3	4	5	6	7	
58.	My job lacks any variety — it is the same old thing over and over.	1	2	3	4	5	6	7	
59.	I have received insufficient training regarding the automated technology and equipment I use.	1	2	3	4	5	6	7	
60.	I am not certain of how much authority I have.	1	2	3	4	5	6	7	
61.	I can't seem to do my job because I am asked to do too many conflicting things.	1	2	3	4	5	6	7	
62.	I have too much work to do to be able to complete it all in a timely fashion.	1	2	3	4	5	6	7	
63.	I can't do a good job with my present skills and abilities.	1	2	3	4	5	6	7	
64.	I am not learning new skills in my job.	1	2	3	4	5	6	7	
65.	I am too responsible for keeping my work group one big happy family.	1	2	3	4	5	6	7	
66.	I am constantly working against the pressure of time.	1	2	3	4	5	6	7	
67.	I am not given enough freedom to do my job as I see fit.	1	2	3	4	5	6	7	
68.	I do not have a sufficient range of software to do my job.	1	2	3	4	5	6	7	Col 72

Appendix E. Electromyography Data Sheet.

Electromyography Data Sheet

		Baseline (μV)	Recovery Time (Secs)	Working Muscle Tension (μV)									Maximum Voluntary Contraction (μV)	Keystroke Rate (000's/hr)	Sex 1 F 2 M	K/B 1-6
AM Arm	Col 1		3													
	5															
	24															
	43												64			
Shoulder	1		4													
	5															
	24															
	43															68
PM Arm	1		5													
	5															
	24															
	43												64			
Shoulder	1		6													
	5															
	24															
	43													66		

1	Manual TW
2	Electric TW
3	VDU WP
4	VDU DE
5	VDU DP
6	Other

Appendix F. Specifications of the Muscle Biofeedback Monitor. (Brown and Mitchell, 1984).

The Muscle Biofeedback Monitor is designed as a stand-alone EMG (electromyography) amplitude measuring instrument, with a biofeedback capacity suitable for use in the workplace. Specifically for occupational health use, it is ergonomically designed so that both EMG measurement **and** biofeedback are correctly incorporated into the instrument. Its main features are:

1. Digital meter measures EMG signals from 0.1 to 1000 microvolts. A digital meter is preferred for measurement because it can be read more accurately than an analogue meter. (Two ranges: 0.1-199.9 microvolts, and 1-1000 microvolts, average EMG.)

2. Large analogue meter for biofeedback. An analogue (pointer-type) meter is preferred for biofeedback because it displays changes in EMG more visibly than a digital meter. (82mm scale length.)

3. Powerful audio feedback signal (adjustable volume) for quiet to moderately loud workplaces, with an earphone/external speaker socket for noisy areas (using a highly recognisable variable-frequency, variable-pulse-rate signal).

4. Precision biofeedback threshold control allows accurate training schedules, essential for new employees and for rehabilitation training (10-turn potenetiometer with 3-digit readout).

5. Highest electrical safety standards. The instrument can only be operated from its rechargeable batteries, ensuring complete freedom from mains-power hazards.

6. Long battery life. Over 100 hours operating time from the internal rechargeable battery which recharges from the supplied charger overnight. (Expected battery life: over 4 years at 40 hours use between charges, 2.5 years at 100 hours use.)

Additional Technical Information

7. Interference-rejecting filters: 100-200 Hz filter. (Hipass filters: 30db step filter and additional 18db/octave below 100 Hz. Lowpass filter: 6db/octave above 200 Hz).
8. Electrodes: readily available disposable cardiac monitoring electrodes. 3M "Red Dot" no. 2248VP is a suitable electrode. [No. 2325VP was used in this study.]
9. Input protection: full protection from static discharge.

	Questions 11 -14 to be answered only by those who have had trouble			
10 **At work,** during the **last 12 months** have you at any time had **trouble** (ache, pain, discomfort) in the:	11 Have you at any time during the **last 12 months been prevented from doing your normal activities** because of the trouble?	12 Have you had **trouble** at work during the **last 7 days?**	13 How **serious** is the trouble you have?	14 What do you think is the **cause** of your trouble?
Neck 1 No 2 Yes Col 27	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	
Shoulders 1 No 2 Yes, in the right shoulder 3 Yes, in the left shoulder 4 Yes, in both shoulders 34	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	
Elbows 1 No 2 Yes, in the right elbow 3 Yes, in the left elbow 4 Yes, in both elbows 41	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	
Wrists/ hands 1 No 2 Yes, in the right wrist/ hand 3 Yes, in the left wrist/ hand 4 Yes, in both wrists/ hands 48	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	
Upper back 1 No 2 Yes 55	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	
Low back (small of the back) 1 No 2 Yes 62	a) At work: 1 No, 2 Yes b) Away from work: 1 No, 2 Yes	1 No 2 Yes	1 Serious 2 Needs attention 3 Not a real worry	

QUESTIONNAIRE ABOUT BACK AND ARM TROUBLE

How to answer the questionnaire:

When several alternative answers are given to a question, please answer by putting a circle around the appropriate answer - one circle for each question except Question 9.

Example:

How do you generally travel to work?
1 Walk
2 Cycle
3 Public transport
4 Private vehicle

Please answer Questions 1 - 9 and every part of Question 10, even if you have never had trouble at work in any part of your body.

Questions 11 - 14 are for those who have had some trouble at work with any of the body parts mentioned.

Use the card to help you decide for yourself in which part you have or have had your trouble (if any).

For the purposes of this questionnaire, **trouble** means **ache, pain** or **discomfort**.

Col 1

1 How long have you been employed to do keyboard work of any kind?

_____ years _____ months

2 Which of the following best describes your present work?

1 Data entry
2 Copy and/or dictaphone typing
3 Customer telephone servicing
4 General secretarial
5 Other (Please specify): ____________________

1

3 How long have you been doing this type of work?

_____ years _____ months

4 Which type of keyboard do you use most in your present work?

1 Manual
2 Electric or electronic
3 VDU word processor
4 VDU data entry
5 VDU data processor
6 Other (Please specify): ____________________

5 On average, how many hours a week do you work? (Include overtime).

_____ hours a week

6 How are you paid for your work?

1 Salary or wages
2 By the number of hours worked
3 By the amount of work done

7 Are you right-handed or left-handed?

1 Right-handed
2 Left-handed

8 In what year were you born?

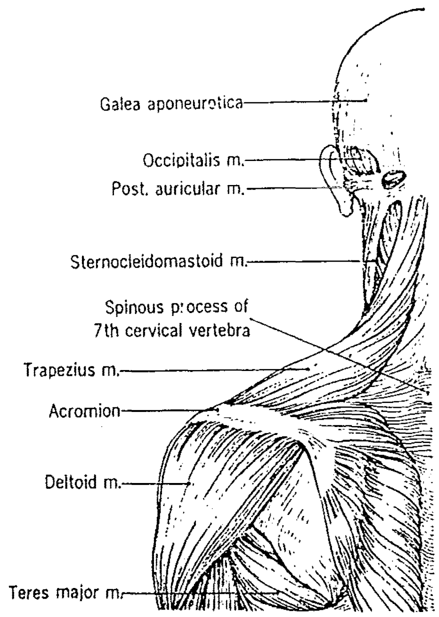
19___

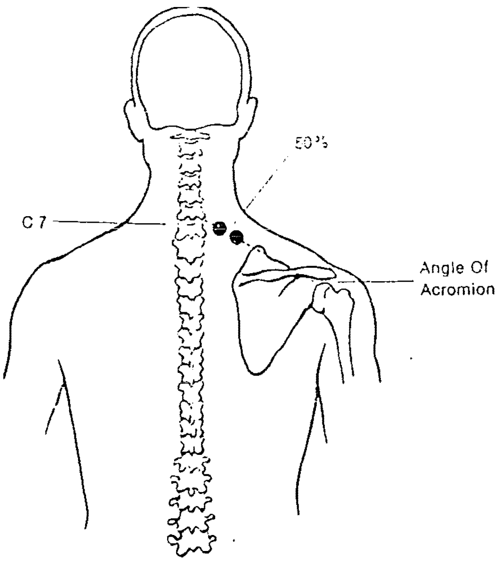
9 The practices in this list may help some people feel more comfortable at keyboard work. Please circle all those which you practise (if any).

1 Frequent short breaks from working
2 Occasional longer breaks (eg 10 mins/hour)
3 Changing the activity
4 Exercises at work to release tension
5 Exercise or sport to keep fit
6 Adjusting the workstation to suit yourself

Col 26

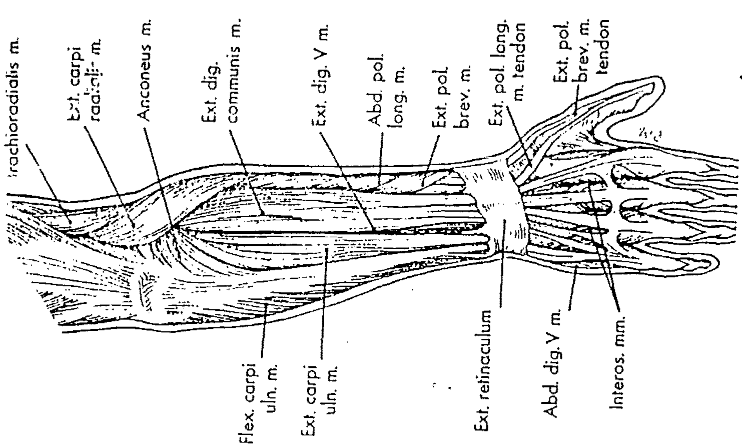
Appendix H. Placement of monitoring electrodes. (Basmajian & Blumenstein, 1980).

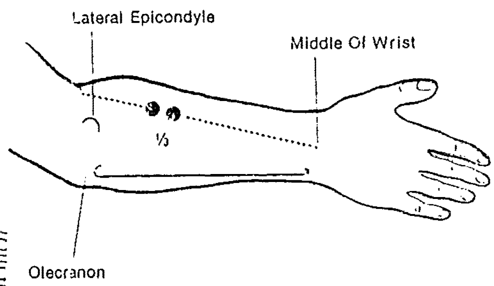




UPPER FIBERS OF TRAPEZIUS

Center the electrodes in a small oval area (about 4cm. long) with its long axis horizontal ½-way between the angle of the acromion and the easily felt spine on vertebra C7.





EXTENSORES CARPI RADIALIS LONGUS & BREVIS

1. With the forearm fully pronated, extend a line from the lateral end of the elbow crease to the middle of the wrist.
2. Center the electrodes on this line around the ⅓ point (straight up the middle of the forearm).